



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵:

G06F 15/332

A2

(11) International Publication Number:

WO 94/23385

(43) International Publication Date:

13 October 1994 (13.10.94)

(21) International Application Number: PCT/GB94/00677

(22) International Filing Date: 30 March 1994 (30.03.94)

(30) Priority Data:

040,301

30 March 1993 (30.03.93)

US

100,747

30 July 1993 (30.07.93)

US

(71)(72) Applicants and Inventors: LEWIS, Adrian, Stafford [GB/ES]; Federico Garcia Lorca 17-5-B, E-07014 Palma (ES). KNOWLES, Gregory, Percy [AU/ES]; Calle Menorca 18-2-B, E-07011 Palma (ES).

(74) Agent: JONES, Ian; W.P. Thompson & Co., Celcon House, 289-293 High Holborn, London WC1V 7HU (GB).

(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TT, UA, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

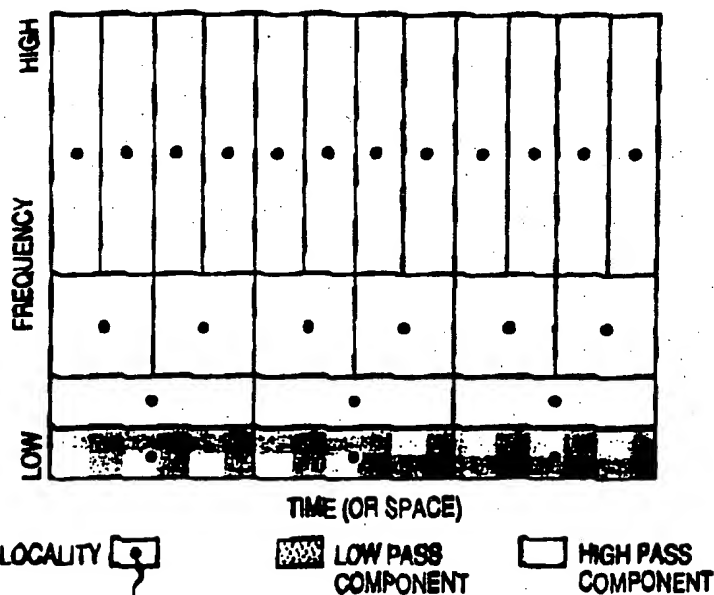
Published

Without international search report and to be republished upon receipt of that report.

(54) Title: DATA COMPRESSION AND DECOMPRESSION

(57) Abstract

A compression and decompression method uses a wavelet decomposition, frequency based tree encoding, tree based motion encoding, frequency weighted quantization, Huffman encoding, and/or tree based activity estimation for bit rate control. Forward and inverse quasi-perfect reconstruction transforms are used to generate the wavelet decomposition and to reconstruct data values close to the original data values. The forward and inverse quasi-perfect reconstruction transforms utilize special filters at the boundaries of the data being transformed and/or inverse transformed. Structures and methods are disclosed for traversing wavelet decompositions. Methods are disclosed for increasing software execution speed in the decompression of video. Fixed or variable length tokens are included in a compressed data stream to indicate changes in encoding methods used to generate the compressed data stream.



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DATA COMPRESSION AND DECOMPRESSION

CROSS REFERENCE TO APPENDICES

5 Appendix A, which is a part of the present disclosure, is a listing of a software implementation written in the programming language C.

 Appendices B-1 and B-2, which are part of the present disclosure, together are a description of a hardware
10 implementation in the commonly used hardware description language ELLA.

 Appendix C, which is part of the present disclosure is a listing of a software implementation written in the programming language C and assembly code.

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20 FIELD OF THE INVENTION

 This invention relates to a method of and apparatus for data compression and decompression. In particular, this invention relates the compression, decompression, transmission and storage of audio, still-image and video
25 data in digital form.

BACKGROUND INFORMATION

 An image such as an image displayed on a computer monitor may be represented as a two-dimensional matrix of digital data values. A single frame on a VGA computer
30 monitor may, for example, be represented as three matrixes of pixel values. Each of the three matrixes has a data value which corresponds to a pixel on the monitor.

 The images on the monitor can be represented by a 640 by 480 matrix of data values representing the luminance

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(brightness) values Y of the pixels of the screen and two other 640 by 480 matrixes of data values representing the chrominance (color) values U and V of the pixels on the screen. Although the luminance and chrominance values are
5 analog values, the one luminance value and the two chrominance values for a pixel may be digitized from analog form into discrete digital values. Each luminance and chrominance digital value may be represented by an 8-bit number. One frame of a computer monitor therefore
10 typically requires about 7 megabits of memory to store in an uncompressed form.

In view of the large amount of memory required to store or transmit a single image in uncompressed digital form, it would be desirable to compress the digital image
15 data before storage or transmission in such a way that the compressed digital data could later be decompressed to recover the original image data for viewing. In this way, a smaller amount of compressed digital data could be stored or transmitted. Accordingly, numerous digital
20 image compression and decompression methods have been developed.

According to one method, each individual digital value is converted into a corresponding digital code. Some of the codes have a small number of bits whereas
25 others of the codes have a larger number of bits. In order to take advantage of the fact that some of the codes are short whereas others of the codes are longer, the original digital data values of the original image are filtered using digital filters into a high frequency component and
30 a low frequency component. The high frequency component represents ambiguities in the image and is therefore observed to have a comparatively large number of identical data values for real-world images. By encoding the commonly occurring digital data values in the high
35 frequency component with the short digital codes, the total number of bits required to store the image data can be reduced from the number of bits that would otherwise be

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required if 8-bits were used to represent all of the data values. Because the total number of bits in the resulting encoded data is less than the total number of bits in the original sequence of data values, the original image is
5 said to have been compressed.

To decompress the compressed encoded data to recover the original image data, the compressed encoded data is decoded using the same digital code. The resulting high and low frequency components are then recombined to form
10 the two-dimensional matrix of original image data values.

Where the data being compressed is two-dimensional data such as image data, separation of the original data into high and low frequency components by the digital filters may be accomplished by filtering in two dimensions
15 such as the horizontal dimension of the image and the vertical dimension of the image. Similarly, decoded high and low frequency components can be recombined into the original image data values by recombining in two dimensions.

20 To achieve even greater compression, the low frequency component may itself be filtered into its high and low frequency components before encoding. Similarly, the low frequency component of the low frequency component may also be refiltered. This process of recursive
25 filtering may be repeated a number of times. Whether or not recursive filtering is performed, the filtered image data is said to have been "transformed" into the high and low frequency components. This digital filtering is called a "transform". Similarly, the high and low pass
30 components are said to be "inverse transformed" back into the original data values. This process is known as the "inverse transform".

Figure 1 is a diagram of a digital gray-scale image of a solid black square 1 on a white background 2
35 represented by a 640 by 480 matrix of 8-bit data luminance values.

Figure 2 is a diagram illustrating a first

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intermediate step in the generation of the high and low frequency components of the original image. A high pass digital filter which outputs a single data value using multiple data values as inputs is first run across the original image values from left to right, row by row, to generate G subblock 3. The number of digital values in G subblock 3 is half of the number of data values in the original image of Figure 1 because the digital filter is sequentially moved to the right by twos to process two additional data values for each additional one data output generated for G subblock 3. Similarly, a low pass digital filter which outputs a single data value using multiple data values as inputs is first run across the original image values from left to right, row by row, to generate H subblock 4. The number of digital values in H subblock 4 is half of the number of data values in the original image because the digital filter is moved to the right by twos to process two additional data values for each additional one data output generated for H subblock 4. Each of the two vertical bars in high pass G subblock 3 appears where a change occurs spatially in the horizontal dimension in the original image of Figure 1. Where the G filter encounters a change from white data values to black data values when the filter G is run across the image of Figure 1 in a horizontal direction, the G digital filter outputs a corresponding black data value into subblock 3. Similarly, when the G digital filter encounters the next change, which is this time a change from black to white data values, the G digital filter again outputs a corresponding black data value into G subblock 3.

Figure 3 is a diagram illustrating a second intermediate step in the generation of the high and low frequency components of the original image. The high pass digital filter is run down the various columns of the subblocks H and G of Figure 2 to form the HG subblock 5 and GG subblock 6 shown in Figure 3. Similarly, the low pass digital filter is run down the various columns of the

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H and G subblocks 3 and 4 of Figure 2 to form HH and GH subblocks 7 and 8 shown in Figure 3. The result is the low pass component in subblock HH and the three high pass component subblocks GH, HG and GG. The total number of high and low pass component data values in Figure 3 is equal to the number of data values in the original image of Figure 1. The data values in the high pass component subblocks GH, HG and GG are referred to as the high frequency component data values of octave 0.

10 The low pass subblock HH is then filtered horizontally and vertically in the same way into its low and high frequency components. Figure 4 illustrates the resulting subblocks. The data values in HHHG subblock 9, HHGH subblock 10, and HHGG subblock 11 are referred to as
15 the high frequency component data values of octave 1. Subblock HHHH is the low frequency component. Although not illustrated, the low frequency HHHH subblock 12 can be refiltered using the same method. As can be seen from Figure 4, the high frequency components of octaves 0 and 1
20 are predominantly white because black in these subblocks denotes changes from white to black or black to white in the data blocks from which the high frequency subblocks are generated. The changes, which are sometimes called edges, from white to black as well as black to white in Figure 1
25 result in high frequency data values in the HG, HG and GG quadrants as illustrated in Figure 3.

Once the image data has been filtered the desired number of times using the above method, the resulting transformed data values are encoded using a digital code
30 such as the Huffman code in Table 1.

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	<u>Corresponding Gray-Scale</u>	<u>Digital Value</u>	<u>Digital Code</u>
5		5	1000001
		4	100001
		3	10001
		2	1001
10	black	1	101
	white	0	0
		-1	111
		-2	1101
		-3	11001
15		-4	110001
		-5	1100001
		.	.
		.	.
		.	.
20		.	.

Table 1

Because the high frequency components of the original image of Figure 1 are predominantly white as is evident from Figures 3 and 4, the gray-scale white is assigned the single bit 0 in the above digital code. The next most common gray-scale color in the transformed image is black. Accordingly, gray-scale black is assigned the next shortest code of 101. The image of Figure 1 is comprised only of black and white pixels. If the image were to involve other gray-scale shades, then other codes would be used to encode those gray-scale colors, the more predominant gray-scale shades being assigned the relatively shorter codes. The result of the Huffman encoding is that the digital values which predominate in the high frequency components are coded into codes having a few number of bits. Accordingly, the number of bits required to represent the original image data is reduced. The image is therefore said to have been compressed.

Problems occur during compression, however, when the digital filters operate at the boundaries of the data values. For example, when the high pass digital filter generating the high pass component begins generating high pass data values of octave 0 at the left hand side of the original image data, some of the filter inputs required by

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the filter do not exist.

Figure 5 illustrates the four data values required by a four coefficient high pass digital filter G in order to generate the first high pass data value G_0 of octave 0. As shown in Figure 5, data values D_1 , D_2 , D_3 and D_4 are required to generate the second high pass data value of octave 0, data value G_1 . In order to generate the first high pass component output data value G_0 , on the other hand, data values D_{-1} , D_0 , D_1 , and D_2 are required. Data value D_{-1} does not, however, exist in the original image data.

Several techniques have been developed in an attempt to solve the problem of the digital filter extending beyond the boundaries of the image data being transformed. In one technique, called zero padding, the nonexistent data values outside the image are simply assumed to be zeros. This may result in discontinuities at the boundary, however, where an object in the image would otherwise have extended beyond the image boundary but where the assumed zeros cause an abrupt truncation of the object at the boundary. In another technique, called circular convolution, the two dimensional multi-octave transform can be expressed in terms of one dimensional finite convolutions. Circular convolution joins the ends of the data together. This introduces a false discontinuity at the join but the problem of data values extending beyond the image boundaries no longer exists. In another technique, called symmetric circular convolution, the image data at each data boundary is mirrored. A signal such as a ramp, for example, will become a peak when it is mirrored. In another technique, called doubly symmetric circular convolution, the data is not only mirrored spatially but the values are also mirrored about the boundary value. This method attempts to maintain continuity of both the signal and its first derivative but requires more computation for the extra mirror because the mirrored values must be pre-calculated

before convolution.

Figure 6 illustrates yet another technique which has been developed to solve the boundary problem. According to this technique, the high and low pass digital filters are moved through the data values in a snake-like pattern in order to eliminate image boundaries in the image data. After the initial one dimensional convolution, the image contains alternating columns of low and high pass information. By snaking through the low pass sub-band before the high pass, only two discontinuities are introduced. This snaking technique, however, requires reversing the digital filter coefficients on alternate rows as the filter moves through the image data. This changing of filter coefficients as well as the requirement to change the direction of movement of the digital filters through various blocks of data values makes the snaking technique difficult to implement. Accordingly, an easily implemented method for solving the boundary problem is sought which can be used in data compression and decompression.

Not only does the transformation result in problems at the boundaries of the image data, but the transformation itself typically requires a large number of complex computations and/or data rearrangements. The time required to compress and decompress an image of data values can therefore be significant. Moreover, the cost of associated hardware required to perform the involved computations of the forward transform and the inverse transform may be so high that the transform method cannot be used in cost-sensitive applications. A compression and decompression method is therefore sought that not only successfully handles the boundary problems associated with the forward transform and inverse transform but also is efficiently and inexpensively implementable in hardware and/or software. The computational complexity of the method should therefore be low.

In addition to transformation and encoding, even

further compression is possible. A method known as tree encoding may, for example, be employed. Moreover, a method called quantization can be employed to further compress the data. Tree encoding and quantization are described in various texts and articles including "Image Compression using the 2-D Wavelet Transform" by A.S. Lewis and G. Knowles, published in IEEE Transactions on Image Processing, April 1992. Furthermore, video data which comprises sequences of images can be compressed by taking advantage of the similarities between successive images. Where a portion of successive images does not change from one image to the next, the portion of the first image can be used for the next image, thereby reducing the number of bits necessary to represent the sequence of images.

JPEG (Joint Photographics Experts Group) is an international standard for still-images which typically achieves about a 10:1 compression ratios for monochrome images and 15:1 compression ratios for color images. The JPEG standard employs a combination of a type of Fourier transform, known as the discrete-cosine transform, in combination with quantization and a Huffman-like code. MPEG1 (Motion Picture Experts Group) and MPEG2 are two international video compression standards. MPEG2 is a standard which is still evolving which is targeted for broadcast television. MPEG2 allows the picture quality to be adjusted to allow more television information to be transmitted, e.g., on a given coaxial cable. H.261 is another video standard based on the discrete-cosine transform. H.261 also varies the amount of compression depending on the data rate required.

Compression standards such as JPEG, MPEG1, MPEG2 and H.261 are optimized to minimize the signal to noise ratio of the error between the original and the reconstructed image. Due to this optimization, these methods are very complex. Chips implementing MPEG1, for example, may be costly and require as many as 1.5 million transistors. These methods only partially take advantage of the fact

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that the human visual system is quite insensitive to signal to noise ratio. Accordingly, some of the complexity inherent in these standards is wasted on the human eye. Moreover, because these standards encode by areas of the image, they are not particularly sensitive to edge-type information which is of high importance to the human visual system. In view of these maladaptions of current compression standards to the characteristics of the human visual system, a new compression and decompression method is sought which handles the above-described boundary problem and which takes advantage of the fact that the human visual system is more sensitive to edge information than signal to noise ratio so that the complexity and cost of implementing the method can be reduced.

SUMMARY

A compression and decompression method using wavelet decomposition, frequency based tree encoding, tree based motion encoding, frequency weighted quantization, Huffman encoding, and tree based activity estimation for bit rate control is disclosed. Forward and inverse quasi-perfect reconstruction transforms are used to generate the wavelet decomposition and to reconstruct data values close to the original data values. The forward and inverse quasi-perfect reconstruction transforms utilize special filters at the boundaries of the data being transformed and/or inverse transformed to solve the above-mentioned boundary problem.

In accordance with some embodiments of the present invention, a decompression method uses four coefficient inverse perfect reconstruction digital filters. The coefficients of these inverse perfect reconstruction digital filters require a small number of additions to implement thereby enabling rapid decompression in software executing on a general purpose digital computer having a microprocessor. The method partially inverse transforms a

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sub-band decomposition to generate a small low frequency component image. This small image is expanded in one dimension by performing interpolation on the rows of the small image and is expanded in a second dimension by replicating rows of the interpolated small image. Transformed chrominance data values are inverse transformed using inverse perfect reconstruction digital filters having a fewer number of coefficients than the inverse perfect reconstruction digital filters used to inverse transform the corresponding transformed luminance data values. In one embodiment, two coefficient Haar digital filters are used as the inverse perfect reconstruction digital filters which inverse transform transformed chrominance data values. Variable-length tokens are used in the compressed data stream to indicate changes in encoding methods used to encode data values in the compressed data stream.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1-4 (Prior Art) are diagrams illustrating a sub-band decomposition of an image.

Figure 5 (Prior Art) is a diagram illustrating a boundary problem associated with the generation of prior art sub-band decompositions.

Figure 6 (Prior Art) is a diagram illustrating a solution to the boundary problem associated with the generation of prior art sub-band decompositions.

Figure 7 is a diagram illustrating a one-dimensional decomposition.

Figures 8 and 9 are diagrams illustrating the separation of an input signal into a high pass component and a low pass component.

Figures 10, 11, 14 and 15 are diagrams illustrating a transformation in accordance with one embodiment of the present invention.

Figures 12 and 13 are diagrams illustrating the operation of high pass and low pass forward transform

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digital filters in accordance with one embodiment of the present invention.

Figure 16 is a diagram of a two-dimensional matrix of original data values in accordance with one embodiment of the present invention.

Figure 17 is a diagram of the two-dimensional matrix of Figure 16 after one octave of forward transform in accordance with one embodiment of the present invention.

Figure 18 is a diagram of the two-dimensional matrix of Figure 16 after two octaves of forward transform in accordance with one embodiment of the present invention.

Figures 19 and 20 are diagrams illustrating a boundary problem solved in accordance with one embodiment of the present invention.

Figure 21 is a diagram illustrating the operation of boundary forward transform digital filters in accordance with one embodiment of the present invention.

Figure 22 is a diagram illustrating the operation of start and end inverse transform digital filters in accordance with one embodiment of the present invention.

Figure 23 is a diagram illustrating a one-dimensional tree structure in accordance one embodiment of the present invention.

Figure 24A-D are diagrams illustrating the recursive filtering of data values to generate a one-dimensional decomposition corresponding with the one-dimensional tree structure of Figure 23.

Figure 25 is a diagram of a two-dimensional tree structure of two-by-two blocks of data values in accordance with one embodiment of the present invention.

Figure 26 is a pictorial representation of the data values of the two-dimension tree structure of Figure 25.

Figures 27-29 are diagrams illustrating a method and apparatus for determining the addresses of data values of a tree structure in accordance with one embodiment of the present invention.

Figure 30 and 31 are diagrams illustrating a

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quantization of transformed data values in accordance with one embodiment of the present invention.

Figures 32 and 33 are diagrams illustrating the sensitivity of the human eye to spatial frequency.

5 Figures 34 is a diagram illustrating the distribution of high pass component data values in a four octave wavelet decomposition of the test image Lenna.

Figure 35 is a diagram illustrating the distribution of data values of the test image Lenna before wavelet
10 transformation.

Figure 36 is a block diagram illustrating a video encoder and a video decoder in accordance with one embodiment of the present invention.

Figure 37 is a diagram illustrating modes of the
15 video encoder and video decoder of Figure 36 and the corresponding token values.

Figure 38 is a diagram illustrating how various flags combine to generate a new mode when the inherited mode is send in accordance with one embodiment of the present
20 invention.

Figures 39-40 are diagrams of a black box on a white background illustrating motion.

Figures 41-43 are one-dimensional tree structures corresponding to the motion of an edge illustrated in
25 Figures 39-40.

Figure 44 is a diagram illustrating variable-length tokens in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

30 QUASI-PERFECT RECONSTRUCTION FILTERS

The wavelet transform was introduced by Jean Morlet in 1984 to overcome problems encountered in analyzing geological signals. See "Cycle-octave and Related Transforms In Seismic Signal Analysis", Goupillaud,
35 Grossman and Morlet, Geoexploration, vol. 23, 1984. Since then, the wavelet transform has been a new and exciting

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method of analyzing signals and has already been applied to a wide range of tasks such as quantum mechanics and signal processing. The wavelet transform has a number of advantages over more traditional Fourier techniques principally used today in the analysis of signals. The wavelet transform and the high and low pass four coefficient quasi-perfect reconstruction filters of the present invention are therefore described by relating them to the windowed Fourier transform.

10 The windowed Fourier transform is the principle transform used today to analyze the spectral components of a signal. The Fourier transform decomposes a signal under analysis into a set of complex sinusoidal basis functions. The resulting Fourier series can be interpreted as the
15 frequency spectra of the signal. The continuous Fourier transform is defined as follows:

$$F(\omega) = \int_{-\infty}^{\infty} e^{-j2\pi\omega t} f(t) dt \quad (\text{equ. 1})$$

Where $f(t)$ is the time domain signal under analysis and $F(\omega)$ is the Fourier transform of the signal under
20 analysis. Although many applications require an estimate of the spectral content of an input signal, the above formula is impractical for most systems. In order to calculate the Fourier transform, the input signal $f(t)$ must be defined for all values of time t , whereas in most
25 practical systems, $f(t)$ is only defined over a finite range of time.

Several methods have therefore been devised to transform the finite input signal into an infinite signal so that the Fourier transform can be applied. The
30 windowed Fourier transform is one such solution. The windowed Fourier transform is defined as follows:

$$F_w(\omega, \tau) = \int_{-\infty}^{\infty} w(t-\tau) e^{-j2\pi\omega t} f(t) dt \quad (\text{equ. 2})$$

Where $f(t)$ is the time domain signal under analysis,

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$F_w(\omega, \tau)$ is the windowed Fourier transform of the time domain signal under analysis, and $w(t)$ is the windowing function. The windowing function is usually chosen to be zero outside an interval of finite length. Alternatively, as the spectral content of the input $f(t)$ varies with time, the input signal can be examined by performing the transform at time τ using a more local window function. In either case, the output transform is the convolution of the window function and the signal under analysis so that the spectra of the window itself is present in the transform results. Consequently, the windowing function is chosen to minimize this effect. Looking at this technique from another viewpoint, the basis functions of a windowed Fourier transform are not complex sinusoids but rather are windowed complex sinusoids. Dennis Gabor used a real Gaussian function in conjunction with sinusoids of varying frequencies to produce a complete set of basis functions (known as Gabor functions) with which to analyze a signal. For a locality given by the effective width of the Gaussian function, the sinusoidal frequency is varied such that the entire spectrum is covered.

The wavelet transform decomposes a signal into a set of basis functions that can be nearly local in both frequency and time. This is achieved by translating and dilating a function $\Psi(t)$ that has spatial and spectral locality to form a set of basis functions:

$$\sqrt{s}\Psi(s(t-u)) \quad (\text{equ. 3})$$

wherein s and u are real numbers and are the variables of the transform. The function $\Psi(t)$ is called the wavelet.

The continuous wavelet transform of a signal under analysis is defined as follows:

$$W(s, u) = \sqrt{s} \int_{-\infty}^{\infty} \Psi(s(t-u)) f(t) dt \quad (\text{equ. 4})$$

Where $f(t)$ is the time domain signal under analysis,

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$W(s,u)$ is its wavelet transform, Ψ is the wavelet, s is the positive dilation factor and u is the scaled translation distance. The spatial and spectral locality of the wavelet transform is dependent on the characteristics of the wavelet.

Because the signal under analysis in the compression of digitally sampled images has finite length, the discrete counterpart of the continuous wavelet transform is used. The wavelet transform performs a multiresolution decomposition based on a sequence of resolutions often referred to as "octaves". The frequencies of consecutive octaves vary uniformly on a logarithmic frequency scale. This logarithmic scale can be selected so that consecutive octaves differ by a factor of two in frequency. The basis functions are:

$$\{\psi^j(x-2^{-j}n)\} \text{ for } (j,n) \in \mathbb{Z}^2 \quad (\text{equ. 5})$$

where \mathbb{Z} is the set of all integers, $\mathbb{Z}^2 = \{(j,n) : j,n \in \mathbb{Z}\}$, and $\psi^j(x) = \sqrt{2^j} \psi(2^j x)$.

In a sampled system, a resolution r signifies that the signal under analysis has been sampled at r samples per unit length. A multiresolution analysis studies an input signal at a number of resolutions, which in the case of the present invention is the sequence $r = 2^j$ where $j \in \mathbb{Z}$. The difference in frequency between consecutive octaves therefore varies by a factor of two.

Stephane Mallat formalized the relationship between wavelet transforms and multiresolution analysis by first defining a multiresolution space sequence $\{V_j\}_{j \in \mathbb{Z}}$, where V_j is the set of all possible approximated signals at resolution 2^j . He then showed that an orthonormal basis for V_j can be constructed by $\{\phi^j(x-2^{-j}n)\}_{n \in \mathbb{Z}}$. $\phi(x)$ is called the scaling function where for any $j \in \mathbb{Z}$, $\phi^j(x) = \sqrt{2^j} \phi(2^j x)$. He then showed that a signal $f(x)$ can be approximated at a resolution 2^j by the set of samples:

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$$S_j = \{\sqrt{2^j} \langle f, \phi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 6})$$

where $\langle f, g \rangle = \int_{-\infty}^{\infty} f(x) g(x) dx$, where $f, g \in L^2(\mathbb{R})$,
 the set of square integrable functions on \mathbb{R} . This is
 equivalent to convolving the signal $f(x)$ with the scaling
 5 function $\phi(-x)$ at a sampling rate of 2^j . However, this
 representation is highly redundant because $V_j \subset V_{j+1}, j \in \mathbb{Z}$.
 It would be more efficient to generate a sequence of
 multiresolution detail signals O_j which represents the
 difference information between successive resolutions
 10 $O_j \oplus V_j = V_{j+1}$ where O_j is orthogonal to V_j . Mallat proved that
 there exists a function $\Psi(x)$ called the wavelet where:

$$\Psi^j(x) = \sqrt{2^j} \Psi(2^j x) \quad (\text{equ. 7})$$

such that $\{\Psi(x-2^j n)\}_{n \in \mathbb{Z}}$ is an orthonormal basis of O_j and
 $\{\Psi(x-2^j n)\}, (j, n) \in \mathbb{Z}^2$, is an orthonormal basis of $L^2(\mathbb{R})$.
 15 The detail signal at resolution 2^{j+1} is represented by the
 set of data values:

$$N_j = \{\sqrt{2^j} \langle f, \Psi_n^j \rangle\}_{n \in \mathbb{Z}} \quad (\text{equ. 8})$$

which is equivalent to convolving the signal $f(x)$ with the
 wavelet $\Psi(-x)$ at a sampling rate of 2^j .

20 Hence, the original signal $f(x)$ can be completely
 represented by the sets of data values $(S_j, (N_j)_{J \leq j \leq -1})$,
 where $J < 0$ gives the number of octaves. This
 representation in the form of data values is known as the
 discrete wavelet decomposition. The S_j notation used by
 25 Mallat refers to recursively low pass filter values of the
 original signal. S_0 corresponds to the original data
 values D . S_1 corresponds to the H data values from the
 low pass filter. N_1 corresponds to the G data values from
 the high pass filter. S_2 corresponds to the next low pass
 30 filtered values from the previous H sub-band. N_2
 corresponds to the next high pass filtered values from the
 previous H sub-band.

If the sampling patterns of the discrete windowed

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Fourier transform and the discrete wavelet transform are compared while maintaining the spatial locality of the highest frequency sample for both transforms, then the efficiency of the discrete wavelet decomposition is revealed. The window Fourier transform produces a linear sampling grid, each data value being a constant spatial distance or a constant frequency away from its neighbor. The result is a heavy over-sampling of the lower frequencies. The wavelet transform, in contrast, samples each of its octave wide frequency bands at the minimum rate such that no redundant information is introduced into the discrete wavelet decomposition. The wavelet transform is able to achieve highly local spatial sampling at high frequencies by the use of octave wide frequency bands. At low frequencies, spectral locality takes precedence over spatial locality.

Figure 7 illustrates the spatial and spectral locality of a sequence of sampled data values. The box surrounding a data value represents the spatial and spectral locality of the data value. The regions of Figure 7 are presented for explanation purposes. In reality there is some overlap and aliasing between adjacent data values, the characteristics of which are determined by the particular wavelet function used.

Mallat showed the wavelet transform can be computed with a pyramid technique, where only two filters are used. Using this technique, S_j and N_j are calculated from S_{j+1} , S_j being used as the input for the next octave of decomposition. A low pass filter H :

$$h(n) = \frac{1}{\sqrt{2}} \langle \phi_0^{-1}, \phi_n^0 \rangle \quad (\text{equ. 9})$$

Mallat showed that S_j can be calculated by convolving from S_{j+1} with H and keeping every other output (i.e. sub-sampling by a factor of 2).

A method for calculating N_j from S_{j+1} can also be derived. This method involves convolving S_{j+1} with a high

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pass filter G and sub-sampling by a factor of 2. The high pass filter G is defined by the following coefficients:

$$g(n) = (-1)^{1-n} h(1-n) \quad (\text{equ. 10})$$

The relationship between the H and G filters results in a large saving when the filters are implemented in hardware.

Figures 8 and 9 illustrate that these two filters H and G form a complementary pair that split an input signal into two half band output signals. Both the high and the low pass outputs can be sub-sampled by a factor of two without corrupting the high frequency information because any aliasing introduced by the sub-sampling will be corrected in the reconstruction. There are the same number of filtered data values as there are original image data values.

The particular wavelet which is best in analyzing a signal under analysis is heavily dependent on the characteristics of the signal under analysis. The closer the wavelet resembles the features of the signal, the more efficient the wavelet representation of the signal will be. In addition, reconstruction errors introduced by quantization resemble the wavelet. Typically, the amount of aliasing varies with spatial support (the number of coefficients of the wavelet filters). Long wavelets can be constructed such that aliasing between adjacent octave bands is minimized. However, the spatial equivalent of aliasing, overlap, increases with filter length. Conversely, short wavelets have little or no overlap spatially but exhibit large amounts of aliasing in the frequency domain. To properly determine the suitability of a wavelet for a particular application, these factors of size and shape must be considered.

To apply the wavelet transform to image processing, the present invention employs a particular wavelet called the four coefficient Daubechies wavelet. Because the four

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coefficient Daubechies wavelet has only four coefficients, it is very short. This is well-suited for analyzing important image features such as object edges. Edges by definition are spatially local discontinuities. Edges often consist of a wide spectral range which, when filtered through a high pass filter, give rise to relatively larger filtered outputs only when the analysis filter coincides with the edge. When the analysis filter does not coincide with the edge, relatively smaller filtered outputs are output by the filter. The shorter the analysis filter used, the more finely the spatial position of the edge is resolved. Longer filters produce more of the relatively larger data values to represent an edge. The shortness of the filter also makes the transform calculation relatively inexpensive to implement compared with that of longer filters or image transformations such as the Fourier or discrete cosine transforms. The four coefficient Daubechies wavelet was selected for use only after a careful analysis of both its spatial and aliasing characteristics. Longer wavelets such as the six coefficient Daubechies wavelet could, however, also be used if a more complex implementation were acceptable. Short filters such as the two coefficients Haar wavelet could also be used if the attendant high levels of noise were acceptable.

The true coefficients of the four coefficient Daubechies wavelet are:

$$a = \frac{1+\sqrt{3}}{8}, b = \frac{3+\sqrt{3}}{8}, c = \frac{3-\sqrt{3}}{8}, d = \frac{-1+\sqrt{3}}{8} \quad (\text{equ. 11})$$

The low pass four coefficient Daubechies digital filter is given by:

$$H\left(\frac{x}{2}\right) = aD(x-1) + bD(x) + cD(x+1) - dD(x+2) \quad (\text{equ. 12})$$

The high pass four coefficient Daubechies digital filter is given by:

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$$G\left(\frac{x}{2}\right) = dD(x-1) + cD(x) - bD(x+1) + aD(x+2) \quad (\text{equ. 13})$$

In equations 12 and 13, $D(x-1)$, $D(x)$, $D(x+1)$ and $D(x+2)$ are four consecutive data values. $H\left(\frac{x}{2}\right)$ and $G\left(\frac{x}{2}\right)$ are true perfect reconstruction filters, i.e. the inverse transform
 5 perfectly reconstructs the original data. For example, when the filters operate on data values $D(1)$, $D(2)$, $D(3)$ and $D(4)$, outputs $H(1)$ and $G(1)$ are generated. Index x in this case would be 2. Due to the presence of the $\frac{x}{2}$ as the index for the filters H and G , the values of x can
 10 only be even integers.

To simplify the computational complexity involved in performing the transformation on real data, the coefficients of the four coefficient Daubechies filter which are non-rational numbers are converted into rational
 15 numbers which can be efficiently implemented in software or hardware. Floating point coefficients are not used because performing floating point arithmetic is time consuming and expensive when implemented in software or hardware.

20 To convert the four Daubechies coefficients for implementation, three relationships of the coefficients a , b , c and d are important. In order for the H filter to have unity gain, the following equation must hold:

$$a + b + c - d = 1 \quad (\text{equ. 14})$$

25 In order for the G filter to reject all zero frequency components in the input data values, the following equation must hold:

$$a - b + c + d = 0 \quad (\text{equ. 15})$$

In order for the resulting H and G filters to be able to
 30 generate a decomposition which is perfectly reconstructible into the original image data the following equation must hold:

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$$ac - bd = 0$$

(equ. 16)

True four coefficient Daubechies filters satisfy the above three equations 14, 15, and 16. However, when the coefficients of the true low and high pass four
 5 coefficient Daubechies filters are converted for implementation, at least one of the three relationships must be broken. In the preferred embodiment, unity gain and the rejection of all zero frequency components are maintained. It is the third relationship of equation 16
 10 that is compromised. Perfect reconstruction is compromised because the process of compressing image data itself inherently introduces some noise due to the tree coding and quantization of the present invention. The reconstructed data values therefore necessarily involve
 15 noise when a real-world image is compressed and then reconstructed. We define filters which satisfy equations 14, and 15 and approximately satisfy equation 16, quasi-perfect reconstruction filters.

Table 2 illustrates a process of converting the
 20 coefficients a, b, c and d for implementation.

$$a = \frac{1+\sqrt{3}}{8} = .3415(32) = 10.92 = \frac{11}{32}$$

$$b = \frac{3+\sqrt{3}}{8} = .5915(32) = 18.92 = \frac{19}{32}$$

$$c = \frac{3-\sqrt{3}}{8} = .1585(32) = 5.072 = \frac{5}{32}$$

$$25 \quad d = \frac{-1+\sqrt{3}}{8} = .0915(32) = 2.928 = \frac{3}{32}$$

Table 2

The true four coefficient Daubechies filter coefficients are listed in the left hand column of Table 2. In the next column to the right, the true coefficients are shown
 30 rounded to four places beyond the decimal point. The

rounded coefficients are scaled by a factor of 32 to achieve the values in the next column to the right. From each value in the third column, an integer value is selected. Which integers are selected has a dramatic effect on the complexity of the software or hardware which compresses the image data. The selected integers are divided by 32 so that the scaling by 32 shown in the second column does not change the values of the resulting converted coefficients.

10 In selecting the integers for the fourth column, the relationship of the three equations 14, 15 and 16 are observed. In the case of $a = 11/32$, $b = 19/32$, $c = 5/32$ and $d = 3/32$, the relationships $a+b+c-d=1$ and $a-b+c+d=0$ both are maintained. Because the converted coefficients
15 in the rightmost column of Table 2 are quite close to the true coefficient values in the leftmost column, the resulting four coefficient filters based on coefficients a , b , c and d allow near perfect reconstruction. On a typical 640 by 480 image, the error between the original
20 and reconstructed data values after forward and then inverse transformation has been experimentally verified to exceed 50 dB.

The resulting high pass four coefficient quasi-Daubechies filter is:

$$25 \quad H\left(\frac{x}{2}\right) = \frac{11}{32}D(x-1) + \frac{19}{32}D(x) + \frac{5}{32}D(x+1) - \frac{3}{32}D(x+2) \text{ (equ. 17)}$$

The resulting low pass four coefficient quasi-Daubechies filter is:

$$G\left(\frac{x}{2}\right) = \frac{3}{32}D(x-1) + \frac{5}{32}D(x) - \frac{19}{32}D(x+1) + \frac{11}{32}D(x+2) \text{ (equ. 18)}$$

Because the high and low pass four coefficient quasi-
30 Daubechies filters satisfy equations 14 and 15 and approximately satisfy equation 16, the high and low pass four coefficient quasi-Daubechies filters are quasi-perfect reconstruction filters.

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Note that the particular converted coefficients of the quasi-Daubechies filters of equations 17 and 18 result in significant computational simplicity when implementation is either software and/or hardware.

5 Multiplications and divisions by factors of two such as multiplications and divisions by 32 are relatively simple to perform. In either hardware or software, a multiplication by 2 or a division by 2 can be realized by a shift. Because the data values being operated on by the
10 digital filter already exist in storage when the filter is implemented in a typical system, the shifting of this data after the data has been read from storage requires little additional computational overhead. Similarly, changing the sign of a quantity involves little additional
15 overhead. In contrast, multiplication and division by numbers that are not a power of 2 require significant overhead to implement in both software and hardware. The selection of the coefficients in equations 17 and 18 allows $H(x)$ and $G(x)$ to be calculated with only additions
20 and shifts. In other words, all multiplications and divisions are performed without multiplying or dividing by a number which is not a power of 2. Due to the digital filter sequencing through the data values, pipelining techniques can also be employed to reduce the number of
25 adds further by using the sums or differences computed when the filters were operating on prior data values.

Moreover, the magnitudes of the inverse transform filter coefficients are the same as those of the transform filter itself. As described further below, only the order
30 and signs of the coefficients are changed. This reduces the effective number of multiplications which must be performed by a factor of two when the same hardware or software implementation is to be used for both the forward and inverse transform. The fact that the signal being
35 analyzed is being sub-sampled reduces the number of additions by a factor of two because summations are required only on the reading of every other sample. The

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effective number of filters is therefore only one to both transform the data into the decomposition and to inverse transform the decomposition back into the image data.

IMAGE COMPRESSION AND DECOMPRESSION USING THE QUASI-PERFECT RECONSTRUCTION TRANSFORM

5 Color images can be decomposed by treating each Red-Green-Blue (or more usually each Luminance-Chrominance-Chrominance channel) as a separate image. In the case of Luminance-Chrominance-Chrominance (YUV or YIQ) images the
10 chrominance components may already have been sub-sampled. It may be desirable therefore, to transform the chrominance channels through a different number of octaves than the luminance channel. The eye is less sensitive to chrominance at high spatial frequency and therefore these
15 channels can be sub-sampled without loss of perceived quality in the output image. Typically these chrominance channels are sub-sampled by a factor of two in each dimension so that they together take only 50 percent of the bandwidth of the luminance channel. When implementing
20 an image compression technique, the chrominance channels are usually treated the same way as the luminance channel. The compression technique is applied to the three channels independently. This approach is reasonable except in the special cases where very high compression ratios and very
25 high quality output are required. To squeeze the last remaining bits from a compression technique or to achieve more exacting quality criteria, knowledge of how the chrominance rather than luminance values are perceived by the human visual system can be applied to improve the
30 performance of the compression technique by better matching it with the human visual system.

Figure 10 is an illustration of a two dimensional matrix of data values. There are rows of data values extending in the horizontal dimension and there are
35 columns of data values extending in the vertical dimension. Each of the data values may, for example, be

an 8-bit binary number of image pixel information such as the luminance value of a pixel. The data values of Figure 10 represent an image of a black box 100 on a white background 101.

5 To transform the data values of the image of Figure 10 in accordance with one aspect of the present invention, a high pass four coefficient quasi-Daubechies digital filter is run across the data values horizontally, row by row, to result in a block 102 of high pass output values G
10 shown in Figure 11. The width of the block 102 of high pass output values in Figure 11 is half the width of the original matrix of data values in Figure 10 because the high pass four coefficient quasi-Daubechies digital filter is moved across the rows of the data values by twos.
15 Because only one additional digital filter output is generated for each additional two data values processed by the digital filter, the data values of Figure 10 are said to have been sub-sampled by a factor of two.

Figure 12 illustrates the sub-sampling performed by
20 the high pass digital filter. High pass output G_1 is generated by the high pass digital filter from data values D_1 , D_2 , D_3 and D_4 . The next high pass output generated, output G_2 , is generated by the high pass digital filter from data values D_3 , D_4 , D_5 and D_6 . The high pass digital
25 filter therefore moves two data values to the right for each additional high pass output generated.

A low pass four coefficient quasi-Daubechies digital filter is also run across the data values horizontally, row by row, to generate H block 103 of the low pass
30 outputs shown in Figure 11. This block 103 is generated by sub-sampling the data values of Figure 10 in the same way the block 102 was generated. The H and G notation for the low and high pass filter outputs respectively is used as opposed to the S_j and O_j notation used by Mallat to
35 simplify the description of the two-dimensional wavelet transform.

Figure 13 illustrates the sub-sampling of the low

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pass digital filter. Low pass output H_1 is generated by the low pass digital filter from data values D_1 , D_2 , D_3 and D_4 . The next low pass output generated, output H_2 , is generated by the low pass digital filter from data values D_3 , D_4 , D_5 and D_6 . The low pass digital filter therefore moves two data values to the right for each additional low pass output generated.

After the high and low pass four coefficient quasi-Daubechies digital filters have generated blocks 102 and 103, the high and low pass four coefficient quasi-Daubechies digital filters are run down the columns of blocks 102 and 103. The values in blocks 102 and 103 are therefore sub-sampled again. The high pass four coefficient quasi-Daubechies digital filter generates blocks 104 and 105. The low pass four coefficient quasi-Daubechies digital filter generates blocks 106 and 107. The resulting four blocks 104-107 are shown in Figure 14. Block 106 is the low frequency component of the original image data. Blocks 107, 104 and 105 comprise the high frequency component of the original image data. Block 106 is denoted block HH. Block 107 is denoted block GH. Block 104 is denoted block HG. Block 105 is denoted block GG.

This process of running the high and low pass four coefficient quasi-Daubechies digital filters across data values both horizontally and vertically to decompose data values into high and low frequency components is then repeated using the data values of the HH block 106 as input data values. The result is shown in Figure 15. Block 108 is the low frequency component and is denoted block HHHH. Blocks 109, 110 and 111 comprise octave 1 of the high frequency component and are denoted HHHG, HHGH, HHGG, respectively. Blocks HG, GH and GG comprise octave 0 of the high frequency component.

Although this recursive decomposition process is only repeated twice to produce high pass component octaves 0 and 1 in the example illustrated in connection with

Figures 10-15, other numbers of recursive decomposition steps are possible. Recursively decomposing the original data values into octaves 0, 1, 2 and 3 has been found to result in satisfactory results for most still image data and recursively decomposing the original data into octaves 0, 1, and 2 has been found to result in satisfactory results for most video image data.

Moreover, the horizontal and subsequent vertical operation of the high and low pass filters can also be reversed. The horizontal and subsequent vertical sequence is explained in connection with this example merely for instructional purposes. The filters can be moved in the vertical direction and then in the horizontal direction. Alternatively, other sequences and dimensions of moving the digital filters through the data values to be processed is possible.

It is also to be understood that if the original image data values are initially arrayed in a two dimensional block as shown in Figure 10, then the processing of the original image data values by the high and low pass filters would not necessarily result in the HH values being located all in an upper right hand quadrant as is shown in Figure 14. To the contrary, depending on where the generated HH values are written, the HH data values can be spread throughout a block. The locations of the HH values are, however, determinable. The HH values are merely illustrated in Figure 14 as being located all in the upper lefthand quadrant for ease of illustration and explanation.

Figure 16 is an illustration showing one possible twelve-by-twelve organization of original image data values in a two dimensional array. Figure 16 corresponds with Figure 10. The location in the array of each data value is determined by a row number and column number. A row number and column number of a data value may, for example, correspond with a row address and column address in an addressed storage medium. This addressed storage

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medium may, for example, be a semiconductor memory, a magnetic storage medium, or an optical storage medium. The row and column may, for example, also correspond with a pixel location including a location of a pixel on a cathode-ray tube or on a flat panel display.

Figure 17 is an illustration showing the state of the two dimensional array after a one octave decomposition. The HH low frequency components are dispersed throughout the two dimensional array as are the HG values, the GH values, and the GG values. The subscripts attached to the various data values in Figure 17 denote the row and column location of the particular data value as represented in the arrangement illustrated in Figure 14. HH_{00} , HH_{01} , HH_{02} , HH_{03} , HH_{04} and HH_{05} , for example, are six data values which correspond with the top row of data values in HH block 106 of Figure 14. HH_{00} , HH_{10} , HH_{20} , HH_{30} , HH_{40} and HH_{50} , for example, are six data values which correspond with the leftmost column of data values in HH block 106 of Figure 14.

When the high and the low pass forward transform digital filters operate on the four data values D_{01} , D_{02} , D_{03} and D_{04} of Figure 16, the output of the low pass forward transform digital filter is written to location row 0 column 2 and the output of the high pass forward transform digital filter is written to location row 0 column 3. Next, the high and low pass forward transform digital filters are moved two locations to the right to operate on the data values D_{03} , D_{04} , D_{05} and D_{06} . The outputs of the low and high pass forward transform digital filters are written to locations row 0 column 4 and row 0 column 5, respectively. Accordingly, the outputs of the low and high frequency forward transform digital filters are output from the filters to form an interleaved sequence of low and high frequency component data values which overwrite the rows of data values in the two dimensional array.

Similarly, when the low and high pass forward

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transform digital filters operate on the four data values at locations column 0, rows 1 through 4, the output of the low pass forward transform digital filter is written to location column 0 row 2. The output of the high pass forward transform digital filter is written to location column 0 row 3. Next the low and high pass forward transform digital filters are moved two locations downward to operate on the data values at locations column 0, rows 3 through 6. The outputs of the low and high pass forward transform digital filters are written to locations column 0 row 4 and column 0 row 5, respectively. Again, the outputs of the low and high pass forward transform digital filters are output from the filters in an interleaved fashion to overwrite the columns of the two dimensional array.

Figure 18 is an illustration showing the state of the two dimensional array after a second octave decomposition. The HHHH low frequency components corresponding which block 108 of Figure 15 as well as the octave 1 high frequency components HHGH, HHMG and HHGG are dispersed throughout the two dimensional array. When the HH values HH_{01} , HH_{02} , HH_{03} and HH_{04} of Figure 17 are processed by the low and high pass forward transform digital filters, the outputs are written to locations row 0 column 4 and row 0 column 6, respectively. Similarly, when the values at locations column 0, rows 2, 4, 6 and 8 are processed by the low and high pass forward transform digital filters, the results are written to locations column 0 row 4 and column 0 row 6, respectively. The data values in Figure 18 are referred to as transformed data values. The transformed data values are said to comprise the decomposition of the original image values.

This method of reading data values, transforming the data values, and writing back the output of the filters is easily expanded to a two dimensional array of a very large size. Only a relatively small number of locations is shown in the two dimensional array of Figures 10-18 for

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ease of explanation and clarity of illustration.

The transformed data values are reconverted back into image data values substantially equal to the original image data by carrying out a reverse process. This
5 reverse process is called the inverse transform. Due to the interleaved nature of the decomposition data in Figure 18, the two digital filters used to perform the inverse transform are called interleaved inverse transform digital filters. Odd data values are determined by an odd
10 interleaved inverse digital filter O. Even data values are determined by the even interleaved inverse transform digital filter E.

The odd and even interleaved inverse digital filters can be determined from the low and high pass forward
15 transform digital filters used in the forward transform because the coefficients of the odd interleaved inverse transform digital filters are related to the coefficients of the low and high pass forward transform filters. To determine the coefficients of the odd and even interleaved
20 inverse transform digital filters, the coefficients of the low and high pass forward transform digital filters are reversed. Where the first, second, third and fourth coefficients of the low pass forward transform digital filter H of equation 17 are denoted a, b, c and -d, the
25 first, second, third and fourth coefficients of a reversed filter H* are denoted -d, c, b and a. Similarly, where the first, second, third and fourth coefficients of the high pass forward transform digital filter G of equation 18 are denoted d, c, -b and a, the first, second, third
30 and fourth coefficients of a reverse filter G* are denoted a, -b, c and d.

The first through the fourth coefficients of the even interleaved inverse transform digital filter E are the first coefficient of H*, the first coefficient of G*, the
35 third coefficient of H*, and the third coefficient of G*. The coefficients of the even interleaved inverse transform digital filter E therefore are -d, a, b and c. In the

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case of the low and high pass four coefficient quasi-Daubechies filters used in the transform where $a = \frac{11}{32}$, $b = \frac{19}{32}$, $c = \frac{5}{32}$ and $d = \frac{3}{32}$, the even interleaved inverse transform digital filter is:

$$5 \quad \frac{D(2x)}{2} = -\frac{3}{32}H(x-1) + \frac{11}{32}G(x-1) + \frac{19}{32}H(x) + \frac{5}{32}G(x) \quad (\text{equ. 19})$$

where $H(x-1)$, $G(x-1)$, $H(x)$ and $G(x)$ are transformed data values of a decomposition to be inverse transformed.

The first through the fourth coefficients of the odd interleaved inverse transform digital filter 0 are the
 10 second coefficient of H^* , the second coefficient of G^* , the fourth coefficient of H^* , and the fourth coefficient of G^* . The coefficients of the odd interleaved inverse transform digital filter 0 therefore are c , $-b$, a and d . In the case of the low and high pass four coefficient
 15 quasi-Daubechies filters used in the transform where $a = \frac{11}{32}$, $b = \frac{19}{32}$, $c = \frac{5}{32}$ and $d = \frac{3}{32}$, the odd interleaved inverse transform digital filter is:

$$\frac{D(2x-1)}{2} = \frac{5}{32}H(x-1) - \frac{19}{32}G(x-1) + \frac{11}{32}H(x) + \frac{3}{32}G(x) \quad (\text{equ. 20})$$

where $H(x-1)$, $G(x-1)$, $H(x)$ and $G(x)$ are data values of a
 20 decomposition to be inverse transformed.

To inverse transform the transformed data values of Figure 18 into the data values of Figure 17, the HHHG, HHGG, HHGH and data values are inverse transformed with the HHHH data values to create the HH data values of
 25 Figure 17. This process corresponds with the inverse transformation of HHHG block 109, HHGH block 110, HHGG block 111, and HHHH block 108 of Figure 15 back into the HH data values of block 106 of Figure 14. The HG, GH and GG data values of Figure 18 are therefore not processed by
 30 the odd and even interleaved inverse transform digital filters in this step of the inverse transform.

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In Figure 18, the odd interleaved inverse transform digital filter processes the values in locations column 0, rows 0, 2, 4 and 6 to generate the odd data value at location column 0 row 2. The even interleaved inverse transform digital filter data also processes the values in the same locations to generate the even data value at location column 0 row 4. The odd and even interleaved inverse transform digital filters then process the values in locations column 0, rows 4, 6, 8 and A to generate the values at locations column 0 row 6 and column 0 row 8, respectively. Each of the six columns 0, 2, 6, 4, 8, and A of the values of Figure 18 are processed by the odd and even interleaved inverse transform digital filters in accordance with this process.

15 The various locations are then processed again by the odd and even interleaved inverse transform digital filters, this time in the horizontal direction. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 0, 2, 4 and 20 6 to generate the values at locations row 0 column 2 and row 0 column 4, respectively. The odd and even interleaved inverse transform digital filters process the values at locations row 0 columns 4, 6, 8 and A to generate the values at locations row 0 column 6 and 25 row 0 column 8, respectively. Each of the six rows 0, 2, 4 and 8 and of values are processed by the even and odd interleaved inverse transform digital filters in accordance with this process. The result is the reconstruction shown in Figure 17.

30 The even and odd interleaved inverse transform digital filters then process the values shown in Figure 17 into the data values shown in Figure 16. This inverse transformation corresponds with the transformation of the HH block 106, the HG block 104, the GH block 107 and the GG 35 block 105 of Figure 14 into the single block of data value of Figure 10. The resulting reconstructed data values of Figure 16 are substantially equal to the original image

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data values.

Note, however, that in the forward transform of the data values of Figure 16 into the data values of Figure 17 that the low and high pass four coefficient quasi-Daubechies digital filters cannot generate all the data values of Figure 17 due to the digital filters requiring data values which are not in the twelve by twelve matrix of data values of Figure 16. These additional data values are said to be beyond the "boundary" of the data values to be transformed.

Figure 19 illustrates the high pass four coefficient quasi-Daubechies digital filter operating over the boundary to generate the G_0 data value. In order to generate the G_0 data value in the same fashion that the other high frequency G data values are generated, the high pass digital filter would require data values D_{-1} , D_0 , D_1 and D_2 as inputs. Data value D_{-1} , however, does not exist. Similarly, Figure 20 illustrates the low pass four coefficient quasi-Daubechies digital filter operating over the boundary to generate the H_0 data value. In order to generate the H_0 data value in the same fashion that the other low frequency H data values are generated, the low pass digital filter would require data values D_{-1} , D_0 , D_1 and D_2 as inputs. Data value D_{-1} , however, does not exist.

The present invention solves this boundary problem by using additional quasi-Daubechies digital filters to generate the data values adjacent the boundary that would otherwise require the use of data values outside the boundary. There is a high pass "start" quasi-Daubechies forward transform digital filter G, which is used to generate the first high pass output G_0 . There is a low pass "start" quasi-Daubechies forward transform digital filter H, which is used to generate the first low pass output H_0 . These start quasi-Daubechies forward transform digital filters are three coefficient filters rather than four coefficient filters and therefore require only three data values in order to generate an output. This allows

the start quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the first forward transform data values without extending over the boundary.

5 Figure 21 illustrates the low and high pass start quasi-Daubechies forward transform digital filters operating at the starting boundary of image data values D_0 through D_3 . The three coefficient low and high pass start quasi-Daubechies forward transform digital filters operate
10 on data values D_0 , D_1 and D_2 to generate outputs H_0 and G_0 , respectively. H_1 , H_2 , H_3 and H_4 , on the other hand, are generated by the low pass four coefficient quasi-Daubechies forward transform digital filter and G_1 , G_2 , G_3 and G_4 are generated by the high pass four coefficient
15 quasi-Daubechies forward transform digital filter.

A similar boundary problem is encountered at the end of the data values such as at the end of the data values of a row or a column of a two-dimensional array. If the low and high pass four coefficient quasi-Daubechies
20 filters G and H are used at the boundary in the same fashion that they are in the middle of the data values, then the four coefficient quasi-Daubechies forward transform digital filters would have to extend over the end boundary to generate the last low and high pass
25 outputs, respectively.

The present invention solves this boundary problem by using additional quasi-Daubechies forward transform digital filters in order to generate the transformed data values adjacent the end boundary that would otherwise
30 require the use of data outside the boundary. There is a low pass "end" quasi-Daubechies forward transform digital filter H_e which is used to generate the last low pass output. There is a high pass "end" quasi-Daubechies forward transform digital filter G_e which is used to
35 generate the last high pass output. These two end quasi-Daubechies forward transform digital filters are three coefficient filters rather than four coefficient filters

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and therefore require only three data values in order to generate an output. This allows the end quasi-Daubechies forward transform digital filters to operate at the boundary and to generate the last transform data values
5 without extending over the boundary.

Figure 21 illustrates two low and high pass end quasi-Daubechies forward transform digital filters operating at the end boundary of the image data. These three coefficient low and high pass end quasi-Daubechies
10 forward transform digital filters operate on data values D_0 , D_1 and D_2 to generate outputs H_0 and G_0 , respectively. This process of using the appropriate start or end low or high pass filter is used in performing the transformation at the beginning and at the end of each row and column of
15 the data values to be transformed.

The form of the low pass start quasi-Daubechies forward transform digital filter H_0 is determined by selecting a value of a hypothetical data value D_1 which would be outside the boundary and then determining the
20 value of the four coefficient low pass quasi-Daubechies forward transform filter if that four coefficient forward transform filter were to extend beyond the boundary to the hypothetical data value in such a way as would be necessary to generate the first low pass output H_0 . This
25 hypothetical data value D_1 outside the boundary can be chosen to have one of multiple different values. In some embodiments, the hypothetical data value D_1 has a value equal to the data value D_0 at the boundary. In some embodiments, the hypothetical data value D_1 is set to zero
30 regardless of the data value D_0 . The three coefficient low pass start quasi-Daubechies forward transform digital filter H_0 therefore has the form:

$$H_0 = K1 + bD_0 + cD_1 - dD_2 \quad (\text{equ. 21})$$

where $K1$ is equal to the product aD_0 , where D_0 is the first
35 data value at the start boundary at the start of a

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sequence of data values, and where a , b , c and d are the four coefficients of the four coefficient low pass quasi-Daubechies forward transform digital filter. If, for example, hypothetical data value D_1 is chosen to be equal to the data value D_0 adjacent but within the boundary, then $K1=aD_0$ where $a = 11/32$ and D_0 is the data value adjacent the boundary, equation 21 then becomes:

$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 22})$$

The form of the high pass start quasi-Daubechies forward transform digital filter G , is determined by the same process using the same hypothetical data value D_1 . The high pass start quasi-Daubechies forward transform digital filter G , therefore has the form:

$$G_0 = K2 + cD_0 - bD_1 + aD_2 \quad (\text{equ. 23})$$

where $K2$ is equal to the product dD_1 , where D_0 is the first data value at the boundary at the start of a sequence of data values, and where a , b , c and d are the four coefficients of the four coefficient high pass quasi-Daubechies forward transform digital filter. If hypothetical data value D_1 is chosen to be equal to D_0 , then equation 23 becomes:

$$G_0 = (d + c)D_0 - bD_1 + aD_2 \quad (\text{equ. 24})$$

The form of the low pass end quasi-Daubechies forward transform digital filter H , is determined in a similar way to the way the low pass start quasi-Daubechies forward transform digital filter is determined. A value of a data value D_c is selected which would be outside the boundary. The value of the four coefficient low pass quasi-Daubechies forward transform digital filter is then determined as if that four coefficient filter were to extend beyond the boundary to data value D_c in such a way

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as to generate the last low pass output H_3 . The three coefficient low pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$H_3 = aD_9 + bD_A + cD_B - K3 \quad (\text{equ. 25})$$

5 where $K3$ is equal to the product dD_C , where D_B is the last data value of a sequence of data values to be transformed, and where a , b , c and d are the four coefficients of the four coefficient low pass quasi-Daubechies filter. D_B is the last data value in the particular sequence of data
10 values of this example and is adjacent the end boundary. In the case where the hypothetical data value D_C is chosen to be equal to the data value D_B adjacent but within the end boundary, then $K3=dD_B$ and equation 25 becomes:

$$H_3 = aD_9 + bD_A + (c-d)D_B \quad (\text{equ. 26})$$

15 The form of the high pass end quasi-Daubechies forward transform digital filter G_3 is determined by the same process using the same data value D_C . The three coefficient high pass end quasi-Daubechies forward transform digital filter therefore has the form:

$$20 \quad G_3 = dD_9 + cD_A - bD_B + K4 \quad (\text{equ. 27})$$

where $K4$ is equal to the product aD_C , where D_B is the last data value in this particular sequence of data values to be transformed, and where a , b , c and d are the four coefficients of the four coefficient high pass quasi-
25 Daubechies forward transform digital filter. D_B is adjacent the end boundary. If hypothetical data value D_C is chosen to be equal to D_B , then equation 27 becomes:

$$G_3 = dD_9 + cD_A + (-b+a)D_B \quad (\text{equ. 28})$$

It is to be understood that the specific low and high

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pass end quasi-Daubechies forward transform digital filters are given above for the case of data values D_0 through D_8 of Figure 21 and are presented merely to illustrate one way in which the start and end digital filters may be determined. In the event quasi-Daubechies filters are not used for the low and high pass forward transform digital filters, the same process of selecting a hypothetical data value or values outside the boundary and then determining the value of a filter as if the filter were to extend beyond the boundary can be used. In some embodiments, multiple hypothetical data values may be selected which would all be required by the digital filters operating on the inside area of the data values in order to produce an output at the boundary. This boundary technique is therefore extendable to various types of digital filters and to digital filters having numbers of coefficients other than four.

As revealed by Figure 22, not only does the forward transformation of data values at the boundary involve a boundary problem, but the inverse transformation of the transformed data values back into original image data values also involves a boundary problem. In the present example where four coefficient quasi-Daubechies filters are used to forward transform non-boundary data values, the inverse transform involves an odd inverse transform digital filter as well as an even inverse transform digital filter. Each of the odd and even filters has four coefficients. The even and odd reconstruction filters alternately generate a sequence of inverse transformed data values.

In Figure 22, the data values to be transformed are denoted $H_0, G_0 \dots H_4, G_4, H_5, G_5$. Where the forward transform processes the rows first and then the columns, the inverse transform processes the columns first and then the rows. Figure 22 therefore shows a column of transferred data values being processed in a first step of the inverse transform. Both the forward and the inverse

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transforms in the described example, however, process the columns in a downward direction and process the rows in a left-right direction.

In Figure 22, the inverse transformed data values reconstructed by the inverse transform digital filters are denoted $D_0, D_1, D_2, D_3 \dots D_B$. The odd inverse transform digital filter outputs are shown on the left and the even inverse transform digital filter outputs are shown on the right.

At the beginning of the sequence of data values $H_0, G_0, H_1, G_1 \dots H_B$ and G_B to be inverse transformed, the four coefficient odd and even inverse transform digital filters determine the values of reconstructed data values D_1 and D_2 using values H_0, G_0, H_1 and G_1 , respectively. Reconstructed data value D_0 , however, cannot be reconstructed from the four coefficient even inverse transform digital filter without the four coefficient even inverse transform digital filter extending beyond the boundary. If the four coefficient even inverse transform filter were to be shifted two data values upward so that it could generate data value D_0 , then the even four coefficient inverse transform digital filter would require two additional data values to be transformed, data values G_1 and H_1 . H_0 is, however, the first data value within the boundary and is located adjacent the boundary.

To avoid the even four coefficient inverse transform digital filter extending beyond the boundary, a two coefficient inverse transform digital filter is used:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 29})$$

in the case where $K1 = aD_0$ and $K2 = dD_0$. D_0 is the first data value and H_0 is the data value to be inverse transformed adjacent the start boundary. This even start inverse transform digital filter has the form of the four coefficient even inverse transform digital filter except that the G_1 data value outside the boundary is chosen to

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be equal to H_0 , and the H_{-1} data value outside the boundary is chosen to be equal to G_0 . The even start inverse transform digital filter therefore determines D_0 as a function of only H_0 and G_0 rather than as a function of H_{-1} , G_{-1} , H_0 and G_0 .

Similarly, a two coefficient odd end inverse transform digital filter is used to avoid the four coefficient odd inverse transform digital filter from extending beyond the end boundary at the other boundary of a sequence of data values to be inverse transformed. The two coefficient odd end inverse transform digital filter used is:

$$D_3 = 4[(c+d)H_3 - (a+b)G_3] \quad (\text{equ. 30})$$

in the case where $K4 = aD_3$ and $K3 = dD_3$. D_3 is the data value to be determined and G_3 is the data value to be inverse transformed adjacent the end boundary. This odd end inverse transform digital filter has the form of the four coefficient odd inverse transform digital filter except that the H_4 data value outside the boundary is chosen to be equal to G_3 and the G_4 data value outside the boundary is chosen to be equal to H_3 . The odd end inverse transform digital filter therefore determines D_3 as a function of only H_3 and G_3 rather than as a function of H_3 , G_3 , H_4 and G_4 .

It is to be understood that the particular even start and odd end inverse transform digital filters used in this embodiment are presented for illustrative purposes only. Where there is a different number of data values to be inverse transformed in a sequence of data values, an even end inverse transform digital filter may be used at the boundary rather than the odd end inverse transform digital filter. The even end inverse transform digital filter is an even inverse transform digital filter modified in accordance with the above process to have fewer coefficients than the even inverse transform digital

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filter operating on the inner data values. Where filters other than quasi-Daubechies inverse transform digital filters are used, start and end inverse transform digital filters can be generated from the actual even and odd 5 inverse transform digital filters used to inverse transform data values which are not adjacent to a boundary. In the inverse transform, the start inverse transform digital filter processes the start of the transformed data values at the start boundary, then the 10 four coefficient inverse transform digital filters process the non-boundary transformed data values, and then the end inverse transform digital filter processes the end of the transformed data values.

The true Daubechies filter coefficients a, b, c and d 15 fulfil some simple relationships which show that the inverse transform digital filters correctly reconstruct non-boundary original image data values.

$$a+c = \frac{1}{2}, b-d = \frac{1}{2}, c+d = \frac{1}{4}, b-a = \frac{1}{4} \quad (\text{equ. 31})$$

and the second order equations:

$$20 \quad ac-bd = 0, a^2+b^2+c^2+d^2 = \frac{1}{2} \quad (\text{equ. 32})$$

Take two consecutive H,G pairs:

$$H\left(\frac{x}{2}\right) = aD(x-1)+bD(x)+cD(x+1)-dD(x+2) \quad (\text{equ. 33})$$

$$G\left(\frac{x}{2}\right) = dD(x-1)+cD(x)-bD(x+1)+aD(x+2) \quad (\text{equ. 34})$$

$$H\left(\frac{x}{2}+1\right) = aD(x+1)+bD(x+2)+cD(x+3)-dD(x+4) \quad (\text{equ. 35})$$

$$25 \quad G\left(\frac{x}{2}+1\right) = dD(x+1)+cD(x+2)-bD(x+3)+aD(x+4) \quad (\text{equ. 36})$$

Multiplying Equations 33 to 36 using the inverse transform digital filters gives:

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$$cH\left(\frac{x}{2}\right) = acD(x-1) + bcD(x) + c^2D(x+1) - cdD(x+2) \quad (\text{equ. 37})$$

$$-bG\left(\frac{x}{2}\right) = -bdD(x-1) - bcD(x) + b^2D(x+1) - abD(x+2) \quad (\text{equ. 38})$$

$$aH\left(\frac{x}{2}+1\right) = a^2D(x+1) + abD(x+2) + acD(x+3) - adD(x+4) \quad (\text{equ. 39})$$

$$dG\left(\frac{x}{2}+1\right) = d^2D(x+1) + cdD(x+2) - bdD(x+3) + adD(x+4) \quad (\text{equ. 40})$$

$$5 \quad -dH\left(\frac{x}{2}\right) = -adD(x-1) - bdD(x) - cdD(x+1) + d^2D(x+2) \quad (\text{equ. 41})$$

$$aG\left(\frac{x}{2}\right) = adD(x-1) + acD(x) - abD(x+1) + a^2D(x+2) \quad (\text{equ. 42})$$

$$bH\left(\frac{x}{2}+1\right) = abD(x+1) + b^2D(x+2) + bcD(x+3) - bdD(x+4) \quad (\text{equ. 43})$$

$$cG\left(\frac{x}{2}+1\right) = cdD(x+1) + c^2D(x+2) - bcD(x+3) + acD(x+4) \quad (\text{equ. 44})$$

Summing equations 37-40 and 41-44 yields:

$$10 \quad cH\left(\frac{x}{2}\right) - bG\left(\frac{x}{2}\right) + aH\left(\frac{x}{2}+1\right) + dG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x-1) + (a^2+b^2+c^2+d^2)D(x+1) + (ac-bd)D(x+3) = D(x+1)/2 \quad (\text{equ. 45})$$

$$-dH\left(\frac{x}{2}\right) + aG\left(\frac{x}{2}\right) + bH\left(\frac{x}{2}+1\right) + cG\left(\frac{x}{2}+1\right) = \\ (ac-bd)D(x) + (a^2+b^2+c^2+d^2)D(x+2) + (ac-bd)D(x+4) = D(x+2)/2 \quad (\text{equ. 46})$$

Using the coefficients of the four coefficient true Daubechies filter, the relationships of equations 31 and 32 hold. Equations 45 and 46 therefore show that with a one bit shift at the output, the original sequence of data 20 values is reconstructed.

Similarly, that the even start reconstruction filter of equation 29 and the odd end reconstruction filter of equation 30 correctly reconstruct the original image data adjacent the boundaries is shown as follows.

25 For the even start filter, with the choice of $K1 = aD_0$ and $K2 = dD_0$ in equations 29 and 30, we have:

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$$H_0 = (a+b)D_0 + cD_1 - dD_2 \quad (\text{equ. 47})$$

$$G_0 = (c+d)D_0 - bD_1 + aD_2 \quad (\text{equ. 48})$$

so

$$bH_0 = b(a+b)D_0 + cbD_1 - dbD_2 \quad (\text{equ. 49})$$

$$cG_0 = c(c+d)D_0 - cbD_1 + acD_2 \quad (\text{equ. 50})$$

$$aH_0 = a(a+b)D_0 + acD_1 - adD_2 \quad (\text{equ. 51})$$

$$dG_0 = d(c+d)D_0 - dbD_1 + adD_2 \quad (\text{equ. 51'})$$

and hence: from equation 29:

$$bH_0 + cG_0 - aH_0 - dG_0 = (b^2 - a^2 + c^2 - d^2)D_0 = \frac{D_0}{4} \quad (\text{equ. 52})$$

10 For the odd end filter, with the choice of $K_3 = dD_B$
and $K_4 = aD_B$, we have:

$$H_3 = aD_9 + bD_A + (c-d)D_B \quad (\text{equ. 53})$$

$$G_3 = dD_9 + cD_A + (a-b)D_B \quad (\text{equ. 54})$$

$$cH_3 = acD_9 + bcD_A + c(c-d)D_B \quad (\text{equ. 55})$$

$$15 -bG_3 = -bdD_9 - bcD_A - b(a-b)D_B \quad (\text{equ. 56})$$

$$dH_3 = daD_9 + bdD_A + d(c-d)D_B \quad (\text{equ. 57})$$

$$-aG_3 = -adD_9 - caD_A - a(a-b)D_B \quad (\text{equ. 58})$$

and hence from equation 30:

$$(c+d)H_3 - (a+b)G_3 = (c^2 - d^2 + b^2 - a^2)D_B = \frac{D_B}{4} \quad (\text{equ. 59})$$

This reveals that the start and end boundary inverse transform digital filters can reconstruct the boundary data values of the original image when low pass and high pass start and end digital filters are used in the forward
5 transform.

TREE ENCODING AND DECODING

As described above, performing the forward quasi-perfect inverse transform does not reduce the number of data values carrying the image information. Accordingly,
10 the decomposed data values are encoded such that not all of the data values need be stored or transmitted. The present invention takes advantage of characteristics of the Human Visual System to encode more visually important information with a relatively larger number of bits while
15 encoding less visually important information with a relatively smaller number of bits.

By applying the forward quasi-perfect inverse transform to a two-dimensional array of image data values, a number of sub-band images of varying dimensions and
20 spectral contents is obtained. If traditional sub-band coding were used, then the sub-band images would be encoded separately without reference to each other except perhaps for a weighting factor for each band. This traditional sub-band encoding method is the most readily-
25 recognized encoding method because only the spectral response is accurately localized in each band.

In accordance with the present invention, however, a finite support wavelet is used in the analysis of an image, so that the sub-bands of the decomposition include
30 spatially local information which indicate the spatial locations in which the frequency band occurs. Whereas most sub-band encoding methods use long filters in order to achieve superior frequency separation and maximal stop band rejection, the filter used in the present invention
35 has compromised frequency characteristics in order to maintain good spatial locality.

Images can be thought of as comprising three components: background intensities, edges and textures. The forward quasi-perfect inverse transform separates the background intensities (the low pass luminance and chrominance bands) from the edge and texture information contained in the high frequency bands. Ideally, enough bandwidth would be available to encode both the edges and the textures so that the image would reconstruct perfectly. The compression due to the encoding would then be entirely due to removal of redundancy within the picture. If, however, the compressed data is to be transmitted and/or stored at low data transmission rates, some visual information of complex images must be lost. Because edges are a visually important image feature, the encoding method of the present invention locates and encodes information about edges or edge-like features for transmission or storage and places less importance on encoding textural information.

There are no exact definitions of what constitutes an edge and what constitutes texture. The present invention uses a definition of an edge that includes many types of textures. An edge or an edge-like feature is defined as a spatially local phenomenon giving rise to a sharp discontinuity in intensity, the edge or edge-like feature having non-zero spectral components over a range of frequencies. Accordingly, the present invention uses a frequency decomposition which incorporates spatial locality and which is invertible. The wavelet transform realized with quasi-perfect inverse transform digital filters meets these requirements.

Because an edge has non-zero components over a range of frequencies of the decomposition in the same locality, an edge can be located by searching through the wavelet decomposition for non-zero data values that represent edges. The method begins searching for edges by examining the low frequency sub-bands of the decomposition. These bands have only a small number of data values because of

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the subsampling used in the wavelet transform and because the spatial support of each low frequency data value is large. After a quick search of the lowest frequency sub-bands, the positions of potential edges are determined.

- 5 Once the locations of the edges are determined in the lowest frequency sub-bands, these locations can be examined at a higher frequency resolutions to confirm that the edges exist and to more accurately determine their spatial locations.
- 10 Figure 23 illustrates an example of a one-dimensional binary search. There are three binary trees arranged from left to right in the decomposition of Figure 23. There are three octaves, octaves 0, 1 and 2, of decomposed data values in Figure 23. The low pass component is not
- 15 considered to be an octave of the decomposition because most of the edge information has been filtered out. Figures 24A-24D illustrate the forward transformation of a one-dimensional sequence of data values D into a sequence of transformed data values such as the tree structure of
- 20 Figure 23. The data values of the sequence of Figure 24A are filtered into low and high frequency components H and G of Figure 24B. The low frequency component of Figure 24B is then filtered into low and high frequency components HH and HG of Figure 24C. The low frequency
- 25 component HH of Figure 24C is then filtered into low and high frequency components HHH and HHG. The transformed data values of HHH block 240 of Figure 24D correspond with the low frequency component data values A, G and M of Figure 23. The transformed data values of HHG block 241
- 30 of Figure 24D correspond with the octave 2 data values B, H and N of Figure 23. The transformed data values of HG block 242 of Figure 24D correspond with the octave 1 data values of Figure 23. Similarly, the transformed data values of G block 243 correspond with the octave 0 data
- 35 values of Figure 23. Although only three trees are shown in Figure 23, the number of HHH data values in block 240 can be large and the size of the tree structure of Figure

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23 can extend in the horizontal dimension in a corresponding manner.

The encoding of a one dimensional wavelet decomposition such as the decomposition of Figure 23 is performed in similar fashion to a binary tree search. The spatial support of a given data value in a given frequency band is the same as two data values in the octave above it in frequency. Thus the wavelet decomposition is visualized as an array of binary trees such as is illustrated in Figure 23, each tree representing a spatial locality. The greater the number of transform octaves, the higher the trees extend upward and the fewer their number.

As illustrated in Figure 23, each of the data values of the decomposition represents a feature which is either "interesting" to the human visual system, or it represents a feature that is "non-interesting" to the human visual system. A data value representing an edge of an object in an image or an edge-like feature is an example of an "interesting" data value. The encoding method is a depth first search, which starts at the trunk of a tree, ascends up the branches of the tree that are interesting, and terminates at the non-interesting branches. After all the branches of a tree have been ascended until a non-interesting data value is encountered or until the top of the branch is reached, the encoding of another tree is begun. Accordingly, as the encoding method follows the interesting data values of Figure 23 from octave 2 to octave 1 to octave 0, the edge is followed from low to high frequency resolution and an increasingly better approximation to the spatial position and shape of the edge is made. Conversely, if at any stage, a non-interesting data value is found, the search is terminated for data values above that non-interesting data value. The higher frequency data values of the tree above a non-interesting data value are assumed to be non-interesting because the corresponding low frequency data

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values did not indicate the presence of an edge at this location. Any interesting data values that do exist in the higher frequency bands above a non-interesting data value in a low frequency band are rejected as noise.

5 The one-dimensional tree structure of Figure 23 is encoded as follows. The low frequency components carry visually important information and are therefore always considered to be "interesting". The method of encoding therefore starts with low frequency component A. This
10 data value is encoded. Next, the octave 2 data value B is tested to determine if it represents an edge or an edge-like feature which is "interesting" to the human visual system. Because data value B is interesting, a token is generated representing that the bits to follow will
15 represent an encoded data value. Interesting data value B is then encoded. Because this tree has not yet terminated, the method continues upward in frequency. Data value C of octave 1 is then tested. For purpose of this example, data value C is considered to be interesting
20 as are data values A, B, C, D, G, H, J, L and M as illustrated in Figure 23. A token is therefore generated indicating an encoded data value will follow. After the token is sent, data value C is encoded. Because this branch has still not terminated in a non-interesting data
25 value, the method continues upward in frequency. Data value D is tested to determine whether or not it is interesting. Because data value D is interesting, a token is generated and data value D is encoded. Because octave 0 is the highest octave in the decomposition, the encoding
30 method tests the other branch originating from previous interesting data value C. Data value E however tests to be non-interesting. A non-interesting token is therefore generated. Data value E is not encoded and does not appear in the compressed data. With both branches
35 originating at data value C terminated, the method proceeds down in frequency to test the remaining branches originating from the previous interesting data value B.

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Data value F is, however, determined to be non-interesting. A non-interesting token is therefore generated and data value F is not encoded and does not appear in the encoded data. Because this branch has
5 terminated, all data values higher in frequency above data value F are considered to be non-interesting. A decoding device receiving the sequence of encoded data values and tokens can determine from the non-interesting token that all corresponding higher frequency data values were
10 considered to be non-interesting by the encoding device. The decoding device can therefore write the appropriate data values as non-interesting and write zeroes to these locations obviating the need for the encoding device to transmit each non-interesting data value above F. With
15 the first tree encoded, the method proceeds to the next low frequency component, data value G. This is a low frequency component and therefore is always considered to be interesting. Data value G is therefore encoded. The method then proceeds to the next tree through blocks H, I,
20 J, K and L in that order generating interesting and non-interesting tokens and encoding interesting data values. Similarly, after the second tree is terminated, low frequency component data value M is encoded. Data value N is determined to be non-interesting so a non-interesting
25 token is sent and the encoding of the third tree is terminated.

In accordance with another embodiment of the present invention, a two-dimensional extension of the one-dimensional case is used. Rather than using binary trees,
30 four branch trees are used. However, to create a practical image encoding method there are also real world factors to take into account. Using a single data value to predict whether the remainder of the tree is zero, is unreliable when dealing with noisy image data. A small
35 two-by-two block of data values is therefore used as the node element in the tree structure of the two-dimensional embodiment. A decision as to whether or not an edge is

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present is based on four data values which is more reliable than a decision based on single data value.

Figure 25 illustrates a tree structure representing a portion of the decomposition of Figure 18. The decomposition of Figure 18 may extend farther to the right and farther in a downward direction for larger two-dimensional arrays of image data values. Similarly, the tree structure of Figure 25 may extend farther to the right for larger arrays of data values. Figure 25 represents a decomposition only having octave 0 and 1 high frequency components. In the event that the decomposition had additional octaves of high frequency components, the tree structure would extend further upward. In contrast to the binary tree structure of Figure 23, the tree structure of Figure 25 is a four branch tree. The two-by-two block of four octave 1 data values HHHG is the root of a tree which extends upward in frequency to four HG two-by-two blocks. If another octave of decomposition were performed, another level of octave 2 high frequency two-by-two blocks would be inserted into the tree structure. Four HHHG octave 1 two-by-two blocks would, for example, have a single octave 2 HHHHHG block beneath them. The low frequency component would be denoted HHHHHH.

Figure 26 is a pictorial representation of the decomposition of the tree structure of Figure 25. As explained above with respect to Figure 15, the actual data values of the various denoted blocks are distributed throughout the two-dimensional array of data values. The two numbers separated by a comma in each of the boxes of Figure 25 denote the row and column of a data value of the two-dimensional array of Figure 18, respectively. Using this tree structure, it is possible to search through the transformed data values of Figure 18 encoding interesting two-by-two blocks of data values and ignoring non-interesting two-by-two blocks.

To describe how the two dimensional encoding method uses the tree structure to search through a decomposition,

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some useful definitions are introduced. First an image *decomp* is defined with dimensions *WIDTH* by *HEIGHT* decomposed to number *OCTS* of octaves. A function *Access* is defined such that given some arguments, the function

5 *Access* outputs the memory address of the specified data value in the wavelet decomposition *decomp*:

```
address = Access (oct, sub, x, y);
```

oct is the octave of the data value sought and is an integer value between 0 (the highest octave) and *OCTS*-1

10 (the number of octaves of transformation *OCTS* minus one). *sub* indicates which of the *HH*, *HG*, *GH* or *GG* bands of the decomposition it is that the data value sought is found. The use of *sub* = *HH* to access the low pass data values is only valid when the value of *oct* is set to that of the

15 lowest octave. The co-ordinates *x* and *y* indicate the spatial location from the top left hand corner of the sub-band specified by *oct* and *sub*. The range of valid values of *x* and *y* are dependent on the octave being accessed. *x* has a range of {0. . . $WIDTH/2^{oct+1}$ }. *y* has a range of {0 .

20 . . $HEIGHT/2^{oct+1}$ }.

Given the function *Access* and a wavelet decomposition, a two-by-two block of data values can be read by the function *ReadBlock*.

```
block = ReadBlock (decomp, oct, sub, x, y) {
25   block[0][0] = decomp[Access(oct, sub, x, y)];
      block[0][1] = decomp[Access(oct, sub, x+1, y)];
      block[1][0] = decomp[Access(oct, sub, x, y+1)];
      block[1][1] = decomp[Access(oct, sub, x+1, y+1)];
}
```

30 The wavelet decomposition is passed to the function *ReadBlock* via the variable *decomp*. The two-by-two block of data values is returned through the variable *block*.

Once a two-by-two block of data values is read, a

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decision is made as to whether the two-by-two block is visually "interesting" and should therefore be encoded or whether it is not and hence should be discarded. The decision is made by a function called *Threshold*. The 5 arguments of the function *Threshold* are *block*, *oct* and *sub*. *Threshold* returns a boolean value *True* if the block is "interesting" and *False* if the block is "non-interesting".

If the block is determined to be interesting by the 10 function *threshold*, it is encoded using a function called *EncodeBlock*. A function *SendToken* inserts a token before the encoded block to inform a decoding device which will later decode the compressed data whether the block to follow the token has been encoded (i.e. *BlockNotEmpty*) or 15 has not been encoded (i.e. *BlockEmpty*). If a block is determined to be interesting, then a *BlockNotEmpty* token is sent, and the block is encoded; next the tree structure above the encoded block is ascended to better determine the location of the edge. The tree encoding procedure 20 *SendTree* is therefore defined recursively as follows:

```

SendTree (decomp, oct, sub, x, y, Q) {
    block = ReadBlock (decomp, oct, sub, x, y);
    If Threshold (block, oct, sub, Q) {
        SendToken (BlockNotEmpty);
    25    EncodeBlock (block, oct, sub, Q);
        If (oct > 0) {
            SendTree (decomp, oct-1, sub, 2*x, 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*(x+1), 2*y, Q);
            SendTree (decomp, oct-1, sub, 2*x, 2*(y+1), Q);
    30    SendTree (decomp, oct-1, sub, 2*(x+1), 2*(y+1), Q);
        }
    } else SendToken (BlockEmpty);
}

```

The procedure *SendTree* is only used to encode high- 35 pass component data values. In procedure *SendTree*

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(*decomp*, *oct*, *sub*, *x*, *y*, *Q*), if the two-by-two block accessed by *ReadBlock* is determined to pass the threshold test, then *SendTree* (*decomp*, *oct*-1, *sub* 2*X, 2*y, *Q*) is used to test one of the next higher two-by-two blocks in the decomposition tree.

The low-pass data values are not considered to form part of the tree structure. The low-pass data values are encoded using another procedure *SendLPF*. In addition, the low-pass values are encoded using a different technique than that used in *EncodeBlock*, so a new procedure *EncodeBlockLPF* is required.

```

SendLPF (decomp, x, y, Q) {
    block = Readblock (decomp, OCTS-1, HH, x, y);
    EncodeBlockLPF (block, OCTS-1, Q);
15 }

```

Accordingly, to encode the entire image, *SendLPF* is applied to all the block locations within the low pass band and *SendTree* is applied to all the block locations in the HG, GH and GG bands, within the lowest octave. A procedure *SendDecomp* is therefore defined that encodes the entire image decomposition:

```

SendDecomp (decomp, Q) {
    For (y=0; y<HEIGHT/2OCTS; y=y+2)
    For (x=0; x<WIDTH/2OCTS; x=x+2) {
25      SendLPF (decomp, x, y, Q);
        SendTree (decomp, OCTS-1, HG, x, y, Q);
        SendTree (decomp, OCTS-1, GH, x, y, Q);
        SendTree (decomp, OCTS-1, GG, x, y, Q);
    }
30 }

```

Accordingly, the above functions define a method for encoding wavelet decomposed images. In terms of speed of encoding for real-world images, many of the trees are

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terminated within the initial octaves so much of the decomposition is not examined. Due to this termination of many trees in the initial octaves, many data values need not be encoded which results in reducing the memory bandwidth and block processing required to implement the compression/decompression method. Provided the functions *Threshold*, *EncodeBlockLPF* and *Access* require only simple calculations, the decomposed data values are rapidly encoded.

10 To implement the function *Access*, a table containing all the addresses of the data values of the two-dimensional tree decomposition may be accessed using the variables *x*, *y*, *sub* and *oct*. For a small image having a small number of data values, this table lookup approach is
 15 reasonable. For images having, for example, approximately 80 different values of *x*, 60 different values of *y*, four different values of *sub*, and 3 or 4 values for *oct*, this table would contain approximately 150,000 10-bit locations. A less memory intensive way of determining the
 20 same *X* and *Y* addresses from the same variables is desirable.

In accordance with one embodiment of the present invention, a function is used to determine the *X* and *Y* addresses from the variables *x*, *y*, *sub* and *oct*. Address
 25 *X*, for example, may be determined as follows:

$$X = ((x \ll 1) + (sub \gg 1)) \ll oct$$

where \ll denotes one shift to the right of value *x* and where \gg denotes one shift to the left.

Address *Y*, for example, may be determined as follows:

30
$$Y = ((y \ll 1) + (1 \& sub)) \ll oct$$

where $\&$ denotes a bit-wise AND function.

In a high performance system, the function *Access* may be implemented according to the following method. The

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recursive function call and the table lookup methods described above are often too slow to implement in real time software or in hardware. Figures 27 and 28 illustrate how the tree decomposition of Figure 25 is traversed in order to generate tokens and encode two-by-two blocks of data values. The X and the Y in Figures 27 and 28 denote coordinate addresses in the two-dimensional matrix of Figure 18. In order to traverse the tree of the decomposition of Figure 25, it is necessary to be able to determine the X and Y addresses of the data values represented in Figure 25. Figure 27 illustrates how the X and Y address of a two-by-two block of data values are determined for those two-by-two blocks of data values located in octave 0 of the decomposition of Figure 25. Similarly, Figure 28 illustrates how the X and Y addresses of the three two-by-two blocks of data values in octave 1 of the decomposition as well as the one two-by-two block of data values of the low pass component of the decomposition of Figure 25 are determined. X as well as Y are each functions of oct, TreeRoot, and sub. The values of sub, and sub, are determined by the sub-band of the two-by-two block of data values sought.

Figure 29 is a chart illustrating the values of sub, and sub, for each sub-band of the decomposition. If, for example, a two-by-two block of data values is sought in the HH band, then the values of sub, and sub, are 0 and 0, respectively. The values TreeRoot, and TreeRoot, together denote the particular tree of a decomposition containing the particular two-by-two block of the data values sought.

In Figures 27 and 28, the rectangles represent digital counters. The arrows interconnecting the rectangles indicate a sequence of incrementing the counters. For example, the right most rectangle in Figure 27, which is called counter C1, has a least significant bit represented in Figure 27 as bit C1, and a most significant bit represented as bit C1. Similarly, the next rectangle to the left in Figure 27 represents a

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digital counter C2 having two bits, a least significant bit C₂, and a most significant bit C₂. The structure of the X, Y address depends on the octave in which the two-by-two block of data values being sought resides. To
5 generate the X, Y address in octave oct = 1, the counter C1 is not included, the sub₁ and sub₂ bits indicating the sub-band bits are shifted one place to the left, and the least significant bits are filled with zeros. The incrementing of the counters in Figure 28 proceeds as
10 illustrated by the arrows.

To determine the X and Y addresses of the four data values of the low pass component HHHH of Figure 25, Figure 28 is used. Because the two-by-two block of data values being sought is a two-by-two block of the low pass
15 component, the values of sub₁ and sub₂ are 0, 0 as required by the table of Figure 29. The C2 counter of Figure 28 increments through the four possible values of C₂, and C₂, to generate the four addresses in the two-by-two block of data values of the HHHH in the low pass component of
20 Figure 25. The value of TreeRoot₁ and TreeRoot₂ are zeroes because this is the first tree of the decomposition. For subsequent trees of the decomposition, TreeRoot₁ and TreeRoot₂ are incremented as illustrated by the arrows in Figure 28 so that the X and Y addresses of the other two-
25 by-two blocks of data values in the low pass component of the tree decomposition can be determined. After this HHHH two-by-two block of data values is located, the four data values are encoded and the search through the tree structure proceeds to the two-by-two block of data values
30 in octave 1 denoted HHHG in Figure 25. To determine the X and Y addresses of the four data values of this two-by-two block, the value of bits sub₁ and sub₂ are changed in accordance with Figure 29. Because this two-by-two block is in the HG sub-band, the values of sub₁ and sub₂ are 0
35 and 1, respectively. The C2 counter is then incremented through its four values to generate the four addresses of the four data values in that block. Supposing, that this

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two-by-two block is determined to be "interesting" then an interesting token is sent, each of the four data values of the block are encoded, and the tree is then ascended to the two-by-two block of data values in octave 0 denoted

5 HG#1. These four addresses are determined in accordance with Figure 27. Because the sub-band is sub-band HG, the values of the bits sub_x and sub_y are 0 and 1, respectively. Counter C1 is then incremented so that the four addresses illustrated in the two-by-two block octave 0 HG#1 of

10 Figure 25 are generated. If the two-by-two block is interesting, then the interesting token is sent and the four data values are encoded. If the two-by-two block is determined not to be interesting, then a non-interesting token is sent and the four data values are not encoded.

15 The search through the tree structure of the decomposition then proceeds to octave 0 block HG#2. After the four addresses of the octave 0 block HG#1 are generated, the C2, bit of the C2 counter is incremented in accordance with the arrows shown in Figure 27. Accordingly, the octave 0

20 block HG#2 is addressed when once again the C1 counter increments through its four states. If the data values of this two-by-two block are determined to be "interesting", an interesting token is sent followed by the encoded data values. If the data values of the two-by-two block are

25 determined to be non-interesting, then a non-interesting token is sent. After all the search of the four two-by-two blocks of the octave 0 HG sub-band are searched, then that HG tree is terminated and the search proceeds to determine the four addresses of the four data values of

30 the octave 1 HHGH two-by-two block. In accordance with this technique, it is possible to traverse the structure of the decomposition and determine the addresses of any two-by-two block in any octave or any sub-band with minimum overhead. Moving between consecutive addresses or

35 descending trees is a simple operation when compared to the snaking address path used by other compression methods such as JPEG.

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When implemented in software, this technique enables real time compression and decompression whereas other techniques may be too slow. If implemented in hardware, this technique provides for a reduced gate count and an efficient implementation. Although this example shows one way of traversing the tree structure of wavelet transform decomposition, it is possible to traverse the tree structure in other ways simply by changing the control structure represented in Figures 27 and 28 to allow for a different traversal of the tree structure. For example, all of the low pass HHHH blocks can be located and encoded first followed by all of the HHHG tree of the decomposition, and then all of the HHGH trees, and then all of the HHGG trees.

15

QUANTIZATION

Each data value of each two-by-two block of the tree decomposition which is determined to be "interesting" is quantized and then Huffman encoded. A linear mid-step quantizer with double-width-0 step is used to quantize each of the data values. Figure 30 is an illustration of the quantization of a 10-bit twos complement data value. The range of the 10-bit data value to be quantized ranges from -512 to 511 as illustrated by the numbers above the horizontal line in Figure 30. This range is broken up into a plurality of steps. Figure 31 represents one such step of data values which extends from 128 to 256 in Figure 30. All incoming data values having values between 128 and 255 inclusive are quantized by dividing the data value by the value $qstep$. Accordingly, the data value A having a value of 150 as illustrated in Figure 31 is divided by the $qstep$ value 128 and results in a $qindex$ number of 1. Integer division is used to generate $qindex$ and the fractional part of the remainder is discarded. Once the $qindex$ number is determined, the $qindex$ number is Huffman encoded. An overall Q value is sent once per frame of compressed data values. The value $qstep$ is

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determined from the overall Q value as described below.

To inverse quantize the $qindex$ number and the $qstep$ value to determine the value of the transformed data values before inverse transformation, the device decoding the incoming quantized values calculates the value of $qstep$ using the value of Q according to a method described below. Once the value of $qstep$ is determined, $qindex$ for a given data value is multiplied by $qstep$.

In the example of Figure 31, $qindex$ value 1 times $qstep$ 128 results in an inverse quantized value of 128. If this inverse quantized value of 128 were used, however, all the data values in the step 128 through 255 would be inverse quantized to the value of 128 at the left end of the step. This would result in unacceptably large errors. On the other hand, if all the data values in the range of Figure 31 were inverse quantized to the mid-step value 191, then less error would result. Accordingly, an inverse quantized value $qvalue$ can be calculated from $qindex$ and $qstep$ as follows:

$$qvalue(qindex, qstep) = \begin{cases} qindex * qstep - \left(\frac{qstep}{2} - 1 \right) & \text{if } qindex < 0 \\ 0 & \text{if } qindex = 0 \\ qindex * qstep + \left(\frac{qstep}{2} - 1 \right) & \text{if } qindex > 0 \end{cases}$$

The human visual system, however, has different sensitivities to quantization errors depending upon the particular sub-band containing the quantized data values. The human visual system performs complex non-linear processing. Although the way the human visual system relates image intensities to recognizable structures is not well understood, it is nevertheless important to take advantage of as much information about the human visual system as possible in order to maximize compression ratio versus picture quality. The wavelet transform approximates the initial image processing performed by the human brain. Factors such as spatial frequency response and Weber's Law can therefore be applied directly to the

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wavelet transformed data values because the transformed data values are in a convenient representation.

Figure 32 shows the sensitivity of the human eye to spatial frequency. Spatial frequency is measured in 5 cycles c per visual angle θ . A screen is positioned at a distance d from an observer as illustrated in Figure 33. A light of sinusoidally varying luminance is projected onto the screen. The spatial frequency is the number of luminance cycles c per visual degree θ at distance d .

10 Note from Figure 32 that the sensitivity of the human eye varies with spatial frequency. Accordingly, the value of $qstep$ is varied depending on the octave and sub-band of the data valve being quantized. The $qstep$ at which a data valve is quantized is determined from the variables

15 oct , sub and Q for that data valve as follows:

$$qstep(oct, sub, Q) = Q * hvs_factor(oct, sub)$$

$$hvs_factor(oct, sub) = \begin{cases} \sqrt{2} & \text{if } sub=GG \\ 1 & \text{otherwise} \end{cases} * \begin{cases} 1.00 & \text{if } oct=0 \\ 0.32 & \text{if } oct=1 \\ 0.16 & \text{if } oct=2 \\ 0.10 & \text{if } oct=3 \end{cases}$$

The scaling factors 1.00, 0.32, 0.16 and 0.10 relate to the spatial frequency scale of Figure 32 to take into

20 account the frequency dependent sensitivity of the human eye.

It is to be understood that scaling factors other than 1.00, 0.32, 0.16 and 0.10 could be used. For example, other scaling factors can be used where the

25 quantizer is used to compress audio data which is received by the human ear rather than by the human eye. Moreover, note that the sub-band GG is quantized more heavily than the other sub-bands because the sub-band GG contains diagonal information which is less important to the human

30 eye than horizontal and vertical information. This method can also be extended down to the level of two-by-two blocks of data values to further tailor the degree of quantization to the human visual system. The function

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hvs_factor which has only two parameters in the presently described embodiment is only one embodiment of the present invention. The function *hvs_factor*, for example, can take into account other characteristics of the human visual system other than *oct* and *sub*, such as the luminance of the background and texture masking.

THRESHOLDING

For each new two-by-two block of data values in the tree decomposition, a decision must be made as to whether the block is "interesting" or "non-interesting". This can be done by the function *threshold*:

$$\text{threshold}(\text{block}, \text{limit}) = \text{limit} > \sum_{y=0}^1 \sum_{x=0}^1 |\text{block}[y][x]| \quad (\text{equ. 60})$$

The sum of the absolute values of the data values of the block *block* is determined as is represented by the double summation to the right of the less than sign and this value is compared to a threshold value *limit*.

"Interesting" blocks are those blocks, for which the sum of the absolute values of the four data values exceeds the value *limit*, whereas "non-interesting" blocks are those blocks for which the sum is less than or equal to the value *limit*.

The value *limit* takes into account the variable quantizer step size *qstep* which varies with octave. For example, a two-by-two block of data values could be determined to pass the test *threshold*, but after quantizing by *qstep* could result in four zero quantized values. For example, all data values between -128 and 127 are quantized to have a quantized *qindex* of zero as is shown in Figure 30 even if some of those data values are determined to correspond with an "interesting" two-by-two block. For this reason, the value *limit* is calculated according to the equation:

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$$\text{limit} = 4 * \text{Bthreshold} * \text{qstep} \quad (\text{equ. 61})$$

In this equation "Bthreshold" is base threshold image factor. In the presently described example, this base threshold is equal to 1.0. The value of 1.0 for the base threshold Bthreshold was determined through extensive experimentation on test images. The factor 4 in equation 61 is included to account for the fact that there are four data values in the block under consideration. In this way blocks are not determined to be interesting, the data values for which the quantizer will later reduce to zeros. This weighted threshold factor limit also reduces the number of operations performed in the quantizer because a fewer number of data values are quantized.

HUFFMAN CODING

The wavelet transform produces transformed data values whose statistics are vastly different from the data values of the original image. The transformed data values of the high-pass sub-bands have a probability distribution that is similar to an exponential or Laplacian characteristic with mean zero.

Figure 34 shows the distribution of high pass data values in a four octave wavelet decomposition of the test image Lenna. Figure 35 shows the distribution of the data values of the test image Lenna before wavelet transformation. The low-pass component data values have a flat distribution that approximates the distribution of luminance and chrominance values in the original image. The high and low pass data values are encoded differently for this reason.

The low pass component data values are encoded by the function *EncodeBlockLPF* as follows:

```

EncodeBlockLPF ( block, OCT-1, Q) {
    Output ( block[0][0]/qstep( OCT-1, HH, Q));
    Output ( block[0][1]/qstep( OCT-1, HH, Q));
    Output ( block[1][0]/qstep( OCT-1, HH, Q));

```

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```
Output ( block[1][1]/qstep( OCT-1, HH, Q));}
```

After encoding, the low-pass data values are quantized and output into the compressed data stream. The low pass data values are not Huffman encoded.

- 5 The high frequency component data values which pass the threshold test are quantized and Huffman encoded to take advantage of their Laplacian distribution. Function *EncodeBlock* performs the quantization and the Huffman encoding for each of the four data values of an
- 10 interesting high frequency component block block. In the function *EncodeBlock*, the variable *sub* is provided so that when function *qstep* is called, different quantization *qstep* values can be used for different high frequency component sub-bands. The function *huffman* performs a
- 15 table lookup to a fixed Huffman code table such as the table of Table 3. The function *EncodeBlock* is defined as follows:

```
EncodeBlock (block, oct, sub, Q) {
    Output(huffman(block[0][0]/qstep(oct, sub, Q)));
20   Output(huffman(block[0][1]/qstep(oct, sub, Q)));
    Output(huffman(block[1][0]/qstep(oct, sub, Q)));
    Output(huffman(block[1][1]/qstep(oct, sub, Q)));
}
```


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<i>qindex</i>	Huffman code
-38 . . . -512	1 1 0 0 0 0 0 0 1 1 1 1 1 1 1 1
-22 . . -37	1 1 0 0 0 0 0 0 1 1 1 1 (<i> qindex </i> -22)
-7 . . -21	1 1 0 0 0 0 0 0 (<i> qindex </i> -7)
5 -6	1 1 0 0 0 0 0 1
.	.
.	.
.	.
-2	1 1 0 1
10 -1	1 1 1
0	0
1	1 0 1
2	1 0 0 1
.	.
15 .	.
.	.
.	.
6	1 0 0 0 0 0 0 1
7 . . 21	1 0 0 0 0 0 0 0 (<i> qindex </i> -7)
22 . . 37	1 0 0 0 0 0 0 0 1 1 1 1 (<i> qindex </i> -22)
20 38 . . 511	1 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1

Table 3

The second bit from the left in the Huffman code of Table 3 is a sign bit. The value $|qindex|-7$ is represented with 4 bits in the case $7 \leq |qindex| \leq 21$. The value $|qindex|-22$ is represented with 4 bits in the case $22 \leq |qindex| \leq 37$.

ENCODING OF TOKENS

At high compression ratios the number of bits in the compressed data stream used by tokens may be reduced by amalgamating groups of "non-interesting" tokens. This can be achieved by introducing new tokens. In accordance with one embodiment of the present invention, two new tokens, *OctEmpty* and *OctNotEmpty* are used. For a high pass component block in a tree above octave zero, there are four branches. The additional pair of tokens indicate

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whether all four are non-interesting. If all four are non-interesting, only a single *OctEmpty* token need be sent. Otherwise, an *OctNotEmpty* token is generated before the four branches are encoded. The particular token scheme described above was selected more to simplify the hardware and software implementations than it was to achieve in the best compression ratio possible. Other methods of representing relatively long sequences of token bits in the compressed data stream using other tokens having a relatively fewer number of bits may be used in place of the tokens *OctEmpty* and *OctNotEmpty* to achieve higher compression ratios.

VIDEO ENCODING AND DECODING

In comparison with the coding of a still image, the successive images of a video sequence typically contain much redundant information. The redundancy of this information is used to reduce the bit rate. If a location in a new frame of the video contains the same or substantially the same information as a corresponding location in the previous old frame of video, that portion of the new frame need not be encoded and introduced into the compressed data. This results in a reduction in the total number of bits in the encoded bit stream.

Figure 36 illustrates a video encoder 31 and a video decoder 32. A video input signal is transformed by a forward wavelet transform block 33, the output of which is written to a new frame store 34. The first frame of video information in the new frame store 34 is referred to as the new frame because no previous frame exists in the old frame store 35 for containing an old frame. A comparison tree encoder 36 therefore generates tokens and transformed data values as described above from the data values output from new frame store 34. The transformed data values are quantized by quantizer 37 into *qindex* levels. These *qindex* levels are then Huffman coded by the Huffman encoder 38. The resulting encoded data values are then

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combined with the tokens in buffer 38A to form a decompressed data bit stream 39.

An essential part of this method is that the old frame present in the video encoder 31 is exactly the same as the old frame 40 present in the video decoder 32. This allows the decoder 32 to be able to correctly decode the encoded bit stream 39 due to the fact that the encoded bit stream contains differences between new and old images and due to the fact that parts of the new frame are not sent due to compression. An inverse quantizer 41 is therefore provided in the video encoder 31 to inverse quantize the *qindex* levels and to store the old frame as sent into old frame store 35 for future comparison with the next frame of the video input signal.

In the video decoder 32, the compressed data stream 39 is received by a buffer 42. The tokens are separated from the Huffman encoded *qindex* levels. The Huffman encoded *qindex* levels are supplied to a Huffman decoder 43, the output of which is supplied to an inverse quantizer 44. The output of the inverse quantizer 44 is written into old frame store 40 under the control of the comparison tree decoder 45. Comparison tree decoder 45 determines what is written into the old frame store 40, depending in part on the tokens received from buffer 42. Once a new frame of transformed data values is present in old frame store 40, an inverse wavelet transform 46 inverse transforms that frame of transformed data values into a corresponding video output signal. To prevent the inverse wavelet transform 46 from overwriting and therefore corrupting the contents of old frame store 40 when it reconstructs data values corresponding to the original new frame data values, an intermediate frame store 47 is maintained.

The octave one HHHG, HHGH, HHGG, and HHHH from Figure 25 are read from the old frame store 40 by the inverse wavelet transform 46 to perform the octave 1 inverse transform as described above. However, the resulting

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octave 0 HH sub-band, output from the inverse wavelet transform 46 is now written to the intermediate frame store 47, so as not to corrupt the old frame store 40. For the octave 0 inverse wavelet transform, the HG, GH, and GG 5 sub-bands are read from the old frame store 40, and the HH sub-band is read from the intermediate frame store 47, to complete the inverse wavelet transform.

When the second frame of compressed video data 39 is received by the video decoder 32, the tokens received by 10 the comparison tree decoder 45 are related to the contents of the previous frame of video information contained in old frame store 40. Accordingly, the video decoder 32 can reconstruct the latest frame of video data using the contents of the frame store 40 and the data values encoded 15 in the compressed data stream 39. This is possible because the compressed data stream contains all the information necessary for the video decoder 32 to follow the same traversal of the tree of the decomposition that the encoder used to traverse the tree in the generation of 20 the compressed data stream. The video decoder 32 therefore works in lock step with the video encoder 31. Both the encoder 31 and the decoder 32 maintain the same mode at a corresponding location in the tree. When the encoder 31 determines a new mode, it incorporates into the 25 compressed data stream 39 a corresponding token, which the video decoder 32 uses to assume that new mode.

Figure 37 illustrates the modes of operation of one possible embodiment of the present invention. To explain the operation of the video encoder 31 and the video 30 decoder 32, an example is provided. The initial frame of the video sequence is processed by the video encoder 31 in still mode. Still mode has three sub-modes: STILL, VOID_STILL, and LPF_STILL. The low pass two-by-two blocks of data values of the decomposition cause the comparison 35 tree encoder 36 of video encoder 31 to enter the LPF_STILL sub-mode. In this sub-mode, the four data values of the two-by-two block are quantized but are not Huffman

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encoded. Similarly, no token is generated. The successive low pass component two-by-two blocks of data values are successively quantized and output into the compressed data stream 39.

5 Next, the lowest frequency octave of one of the sub-bands is processed by the comparison tree encoder 36. This two-by-two block of data values corresponds with block HHHG illustrated in Figure 25. The four data values of this two-by-two block are tested against the threshold
10 limit to determine if it is "interesting". If the two-by-two block HHHG is interesting, then a single bit token 1 is generated, as illustrated in Figure 37, the mode of the comparison tree encoder remains in STILL mode, and the four data values of the two-by-two block HHHG are
15 successively quantized and encoded and output into the compressed data stream 39.

For the purposes of this example, block HHHG is assumed to be interesting. The tree structure of Figure 25 is therefore ascended to octave 0 two-by-two block
20 HG#1. Because the comparison tree encoder 31 remains in the STILL mode, this block is encoded in the STILL mode. The four data values of block HG#1 are tested to determine whether or not they are interesting. This sequence of testing the successive blocks of the tree structure is
25 repeated as described above.

After the traversal of the four octave 0 sub-blocks HG#1, HG#2, HG#3 and HG#4, the comparison tree encoder 36 proceeds in the tree structure to the two-by-two block of data values in octave 1, block HHGH. For purposes of this
30 example, this two-by-two is non-interesting. After the comparison tree encoder 36 reads the four data values, the result of the threshold test indicates a non-interesting two-by-two block. As illustrated in Figure 37, the encoder 31 which is in the still mode now generates a
35 single bit token 0 and the comparison tree encoder 36 enters the VOID_STILL sub-mode. Although no additional information is output into the compressed data stream 39,

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the comparison tree encoder 36 proceeds to write 0's into the four locations of the two-by-two block HHGH, as well as all the locations of the two-by-two blocks in the tree above the non-interesting two-by-two block HHGH. In the example of Figure 25, the comparison tree encoder 36 writes 0's into all the addresses of blocks HHGH, GH#1, GH#2, GH#3 and GH#4. This zeroing is performed because the video decoder 32 will not be receiving the data values corresponding to that tree. Rather, the video decoder 32 will be receiving only a non-interesting token, a single bit 0. The video decoder 32 will therefore write zeros into frame store 40 in the remainder of the corresponding tree. In order to make sure that both the video encoder 31 and the video decoder 32 have exactly the same old frame 35 and 40, the video encoder too must zero out those non-interesting blocks.

After the first frame of video data has been encoded and sent in STILL mode, the next frame of video data is processed by the video encoder 31. By default, the encoder now enters SEND mode. For lowpass frequency component two-by-two blocks, the video encoder 31 enters the LPF_SEND mode as illustrated in Figure 37. The encoding of such a lowpass component two-by-two block corresponds with the encoding of two-by-two block HHHH in Figure 25. However, now the comparison tree encoder 36 has both a new frame in frame store 34 as well as an old frame in frame store 35. Accordingly, the comparison tree encoder 36 determines the arithmetic difference of the respective four data values in the new frame from the four data values in the old frame at the corresponding position and compares the sum of those differences with a compare threshold. The compare threshold, compare, is calculated from a base compare threshold "Bcompare" as in the case of the previous threshold which determines which blocks are interesting, similar to equations 60 and 61. If the sum of the differences is less than the compare threshold, then the video encoder 31 sends a single bit token 0 and

remains in the LPF_SEND mode, as illustrated in Figure 37. The video encoder 31 does not transmit any data values corresponding to the lowpass frequency component two-by-two block.

5 If, on the other hand, the sum of the arithmetic differences exceeds the compare threshold, then a single bit token 1 is generated, as illustrated in Figure 37. In this case, the video encoder 31 sends the arithmetic differences of each of the successive four data values of
10 the new frame versus the old frame to the quantizer 37 and then to the Huffman encoder 38. The arithmetic differences are encoded and sent rather than sending the actual data values because this results in fewer bits due to the fact that the two blocks in the new and old frames
15 are quite similar under normal circumstances.

When the video encoder 31 proceeds to encode the octave 1 sub-band HHHG, as illustrated in Figure 25, the video encoder 31 enters the SEND mode, as illustrated in Figure 37. In this mode, the comparison tree encoder 36
20 compares the data values of the new two-by-two block with the data values of the old two-by-two block and performs a series of arithmetic operations to generate a series of flags, as illustrated in Figure 38. Based on these flags, the video encoder 31 generates a 2-bit token and enters
25 one of four new modes for that two-by-two block. If, for example, the two-by-two block HHHG in Figure 25 is received by the video encoder 31, then flags ozflag, nzflag, new_z, noflag, motion, origin, and no_z are determined. The values of these flags are determined as:

$$30 \quad nz = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y]| \quad (\text{equ. 62})$$

$$no = \sum_{x=0}^1 \sum_{y=0}^1 |new[x][y] - old[x][y]| \quad (\text{equ. 63})$$

$$oz = \sum_{x=0}^1 \sum_{y=0}^1 |old[x][y]| \quad (\text{equ. 64})$$

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$nzflag = nz < limit$ (equ. 65)
 $noflag = no < compare$ (equ. 66)
 $origin = nz \leq no$ (equ. 67)
 $motion = ((nz + oz) \ll oct) \leq no$ (equ. 68)
5 $new_z = |new[x][y]| < qstep, 0 \leq x, y, \leq 1$ (equ. 69)
 $no_z = |new[x][y] - old[x][y]| < qstep, 0 \leq x, y \leq 1$ (equ. 70)
 $ozflag = \{old[x][y] = 0; \text{ for all } 0 \leq x, y \leq 1\}$ (equ. 71)

Based on the values of these flags, the new mode for
10 the two-by-two block HHHG is determined, from Figure 38.

If the new mode is determined to be the SEND mode, the 2-bit token 11 is sent as indicated in Figure 37. The arithmetic differences of the corresponding four data values are determined, quantized, Huffman encoded, and
15 sent into the compressed data stream 39.

In the case that the flags indicate the new mode is STILL_SEND, then the 2-bit token 01 is sent and the new four data values of the two-by-two block are quantized, Huffman encoded, and sent. Once having entered the
20 STILL_SEND mode, the video encoder 31 remains in the STILL_SEND mode until the end of the tree has been reached. In this STILL_SEND mode, a single bit token of either 1 or 0 precedes the encoding of each block of data values. When the VOID mode is entered from STILL_SEND
25 mode, the video encoder 31 generates a single bit 0 token, then places zeros in the corresponding addresses for that two-by-two block, and then proceeds to place zeros in the addresses of data values of the two-by-two blocks in the tree above.

30 In the event that the flags indicate that the video encoder 31 enters the VOID mode from SEND mode, a 2-bit token 10 is generated and the four data values of that two-by-two block are replaced with zeros. The VOID mode also results in the video encoder 31 placing zeros in all
35 addresses of all data values of two-by-two blocks in the tree above.

In the case that the flags indicate that there is no

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additional information in the tree being presently encoded, namely, the new and the old trees are substantially the same, then a 2-bit token of 00 is generated and the video encoder 31 proceeds to the next 5 tree in the decomposition.

In general, when the video encoder 31 enters VOID mode, the video encoder will remain in VOID mode until it determines that the old block already contains four zero data values. In this case, there is no reason to continue 10 in VOID mode writing zeros into that two-by-two block or the remainder of the blocks in the tree above because it is guaranteed that the old tree already contains zeros in these blocks. This is true because the old tree in frame store 35 has previously been encoded through the inverse 15 quantizer 41.

Because the video decoder 32 is aware of the tree structure of the decomposition, and because the video encoder 31 communicates with the video decoder 32 using tokens, the video decoder 32 is directed through the tree 20 structure in the same manner that the video encoder 31 traverses the tree structure in generating the compressed data stream 39. In this way the video decoder 32 writes the appropriate data values from the decompressed data stream 39 into the corresponding positions of the old data 25 frame 40. The only flag needed by the video decoder 32 is the *ozflag*, which the video decoder obtains by reading the contents of old frame store 40.

RATE CONTROL

All transmission media and storage media have a 30 maximum bandwidth at which they can accept data. This bandwidth can be denoted in terms of bits per second. A standard rate ISDN channel digital telephone line has, for example, a bandwidth of 64 kbits/sec. When compressing a sequence of images in a video sequence, depending upon the 35 amount of compression used to compress the images, there may be a relatively high number of bits per second

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generated. This number of bits per second may in some instances exceed the maximum bandwidth of the transmission media or storage device. It is therefore necessary to reduce the bits per second generated to insure that the maximum bandwidth of the transmission media or storage device is not exceeded.

One way of regulating the number of bits per second introduced into the transmission media or storage device involves the use of a buffer. Frames having a high number of bits are stored in the frame buffer, along with frames having a low number of bits, whereas the number of bits per second passing out of the buffer and into the transmission media or storage device is maintained at a relatively constant number. If the buffer is sufficiently large, then it is possible to always achieve the desired bit rate as long as the overall average of bits per second being input into the buffer over time is the same or less than the maximum bit rate being output from the buffer to the transmission media or storage device.

There is, however, a problem associated with large buffers in video telephony. For a large buffer, there is a significant time delay between the time a frame of video data is input into the buffer and time when this frame is output from the video buffer and into the transmission media or storage device. In the case of video telephony, large buffers may result in large time delays between the time when one user begins to speak and the time when another user begins to hear that speech. This time delay, called latency, is undesirable. For this reason, buffer size is specified in the standard H.261 for video telephony.

In accordance with one embodiment of the present invention, a rate control mechanism is provided which varies the number of bits generated per frame, on a frame by frame basis. Due to the tree encoding structure described above, the number of bits output for a given frame is dependent upon the number of trees ascended in

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the tree encoding process. The decisions of whether or not to ascend a tree are made in the lowest high frequency octaves of the tree structure. As can be seen from Figure 25, there are relatively few number of blocks in the lowest frequency of the sub-bands, as compared to the number of blocks higher up in the sub-band trees. Given a particular two-by-two block in the tree structure, it is possible to decrease the value of Q in the equation for the threshold limit until that particular block is determined to be "interesting". Accordingly, a particular Q is determined at which that particular block becomes interesting. This process can be done for each block in the lowest frequency HG, GH and GG sub-bands. In this way, a histogram is generated indicating a number of two-by-two blocks in the lowest frequency of the three sub-bands which become interesting at each particular value of Q .

From this histogram, a relationship is developed of the total number of two-by-two blocks in the lowest frequency of the three sub-bands which are interesting for a given value of Q . Assuming that the number of blocks in the lowest frequency octave of the three sub-bands which are interesting for a given value of Q is representative of the number of bits which will be generated when the tree is ascended using that given value of Q , it is possible to determine the value of Q at which a desired number of bits will be generated when that frame is coded with that value of Q . Furthermore, the greater the threshold is exceeded, the more bits may be needed to encode that tree. It is therefore possible to weight by Q the number of blocks which are interesting for a given value of Q . Finally, the Q values so derived should be averaged between frames to smooth out fluctuations.

The encoder model RM8 of the CCITT Recommendation H.261 is based on the DCT and has the following disadvantages. The rate control method used by RM8 is a linear feedback technique. Buffer fullness is

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proportional to Q . The value of Q must be adjusted after every group of blocks (GOB) to avoid overflow or underflow effects. This means that parts of the image are transmitted at a different level quality from other parts.

5 During parts of the image where little change occurs, Q drops which can result in uninteresting areas being coded very accurately. The objects of interest are, however, usually the moving ones. Conversely, during the coding of areas of high activity, Q rises creating large errors in
10 moving areas. When this is combined with a block based transform, the errors can become visually annoying.

The method of rate control described in connection with one embodiment of the present invention uses one value of Q for the whole frame. The value of Q is only
15 adjusted between frames. All parts of an image are therefore encoded with the same value of Q . Moreover, because the tree structure allows a relatively few number of blocks to be tested to determine an estimate of the number of bits generated for a given frame, more
20 intelligent methods of varying Q to achieve an overall desired bit rate are possible than are possible with conventional compression/decompression techniques.

TREE BASED MOTION ESTIMATION

Figure 39 represents a black box 1 on a white
25 background 2. Figure 40 represents the same black box 1 on the same white background 2 moved to the right so that it occupies a different location. If these two frames of Figures 39 and 40 are encoded according to the above described method, there will be a tree in the wavelet
30 decomposition which corresponds with the white-to-black edge denoted 3 in Figure 39. Similarly, there will be another tree in the wavelet decomposition of the image of Figure 40 which represents the white-to-black edge 3' the wavelet decomposition of the image of Figure 40. All of
35 the data values corresponding to these two trees will be determined to be "interesting" because edges result in

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interesting data values in all octaves of the decomposition. Moreover, due to the movement of the corresponding edge of black box 1, all the data values of the edges of both of these two trees will be encoded as interesting data values in the resulting compressed data stream. The method described above therefore does not take into account that it is the same data values representing the same white-to-black edge which is present in both images but which is just located at a different location.

Figure 41 is a one dimensional representation of an edge. The corresponding low path component data values are not illustrated in Figure 41. Data values 4, 5, 6, 7, 8, and 9 represent the "interesting" data values of Figure 41 whereas the other data values have low data values which makes those blocks "non-interesting". In the representation of Figure 41, data values 4 and 5 are considered a single two data value block. Similarly, blocks 6 and 7 are considered a single block and blocks 8 and 9 are considered a single block. Figure 41, although it is a one dimensional representation for ease of illustration, represents the edge 3 of the frame of Figure 39.

Figure 42 represents the edge 3' shown in Figure 40. Figure 42 indicates that the edge of black box 1 has moved in location due to the fact that the values 19 and 21 which in Figure 41 were in the two data value block 8 and 9 are located in Figure 42 in the two data value block 10 and 11. In the encoding of Figure 42, rather than encoding and sending into the compressed data stream the values 19 and 21, a control code is generated which indicates the new locations of the two values. Although numerous control codes are possible, only one embodiment is described here.

When the two data value block 10 and 11 is tested to determine whether it is interesting or not, the block tests to be interesting. The neighboring blocks in the

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old frame are, however, also tested to determine whether the same values are present. In this case, the values 19 and 21 are determined to have moved one two data value block to the right. An "interesting with motion" token is therefore generated rather than a simple "interesting" token. A single bit 1 is then sent indicating that the edge represented by values 19 and 21 has moved to the right. Had the edge moved to the left, a control code of 0 would have been sent indicating that the edge represented by values 19 and 21 moved one location to the left. Accordingly, in the encoding of Figure 42, an "interesting with motion" token is generated followed by a single control code 1. The interesting values 19 and 21 therefore need not be included in the compressed data stream. The video decoder receiving this "interesting with motion" token and this control code 1 can simply copy the interesting values 19 and 21 from the old frame into the indicated new location for these values in the new frame obviating the need for the video encoder to encode and transmit the actual interesting data values themselves. The same token and control codes can be sent for the two data values corresponding to a block in any one of the octaves 0, 1 or 2.

Figure 43 represents the motion of the edge 3 of Figure 39 to a new location which is farther removed than is the new location of black box 1 shown in Figure 40. Accordingly, it is seen that the values 20 and 21 are located to the right at the two data value block 12 and 13. In the encoding of this two data value block 12 and 13 a token indicating "interesting with motion" is generated. Following that token, a control code 1 is generated indicating motion to the right. The video encoder therefore need not encode the data values 20 and 21 but merely needs to generate the interesting with motion token followed by the motion to the right control code. When the video encoder proceeds to the two data values block 14 and 15, the video encoder need not send

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the "interesting with motion" token but rather only sends the left control code 0. Similarly, when the video encoder proceeds to encode the two data value block 16 and 17, the video encoder only sends the left control code 0.

5 The control codes for octaves 0 and 1 do not denote motion per se but rather denote left or right location above a lower frequency interesting block of the moving edge. This results in the video encoder not having to encode any of the actual data values representing the moved edge in

10 the decomposition of Figure 43.

The one dimensional illustration of Figures 41, 42 and 43 is presented for ease of illustration and explanation. It is to be understood, however, that this method of indicating edge motion is used in conjunction

15 with the above described two dimensional wavelet decomposition such as the two dimensional wavelet decomposition illustrated in Figure 25. The video encoder searches for movement of the data values representing an edge only by searching the nearest neighboring blocks of

20 data values in the old frame. This method can be used to search many neighbors or a few neighbors depending on the application. The counter scheme described in connection with Figures 27 and 28 can be used to determine the locations of those neighboring blocks. Although the edge

25 motion illustrated in connection with Figures 41, 42, and 43 shows the very same data values being moved in the tree structure of the decomposition, it is to be understood that in practice the values of the data values representing the same edge may change slightly with the

30 movement of the edge. The video encoder takes this into account by judging corresponding data values using a motion data value threshold to determine if corresponding data values in fact do represent the same edge. By indicating edge motion and not sending the edge data

35 values themselves it is possible to both increase the compression and also improve the quality of the decompressed image.

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SIX COEFFICIENT QUASI-DAUBECHIES FILTERS

The Daubechies six coefficient filters are defined by the six low pass filter coefficients, listed in the table below to 8 decimal places. The coefficients are also defined in terms of four constants, α , β , γ and ϵ , where $\alpha = 0.10588942$, $\beta = -0.54609641$, $\gamma = 2.4254972$ and $\epsilon = 3.0059769$.

	Daubechies coefficients	Alternative representation	Normalized coefficients	Converted Coefficients
a	0.33267055	$1/\epsilon$	0.2352336	$\frac{30}{128}$
b	0.80689151	γ/ϵ	0.57055846	$\frac{73}{128}$
c	0.45987750	$-\beta(\alpha+\gamma)/\epsilon$	0.3251825	$\frac{41}{128}$
-d	-0.13501102	$\beta(1 - \alpha\gamma)/\epsilon$	-0.095467208	$\frac{-12}{128}$
-e	-0.08544127	$-\alpha\gamma/\epsilon$	-0.060416101	$\frac{-7}{128}$
f	0.03522629	α/ϵ	0.024908749	$\frac{3}{128}$

Table 4

The coefficients (a, b, c, -d, -e, f) sum to $\sqrt{2}$. The normalized coefficients sum to 1, which gives the filter the property of unity gain, which in terms of the alternative representation is equivalent to a change in the value of ϵ to 4.2510934. These values can be approximated to any given precision by a set of fractions. In the example shown above, each of the normalized values has been multiplied by 128 and rounded appropriately, thus the coefficient a has been converted to $\frac{30}{128}$. Filtering is therefore possible using integer multiplications rather than floating point arithmetic. This greatly reduces implementation cost in terms of digital hardware gate count and computer software speed. The following equations show a single step in the filtering process, the outputs H and G being the low and high pass outputs, respectively:

$$H_1 = aD_0 + bD_1 + cD_2 - dD_3 - eD_4 + fD_5 \quad (\text{equ. 72})$$

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$$G_1 = -fD_0 - eD_1 + dD_2 + cD_3 - bD_4 + aD_5 \quad (\text{equ. 73})$$

H_1 and G_1 are calculated as follows. Each data value D is multiplied by the relevant integer numerator (30, 73, 41, 12, 7, 3) and summed as shown. The values of H and G are found by dividing the summations by the constant 128. Because 128 is an integer power of 2, the division operation requires little digital hardware to implement and only simple arithmetic shift operations to implement in software. The filters H and G are quasi-perfect reconstruction filters:

$$a+b+c-d-e+f=1 \quad (\text{equ. 74})$$

$$-f-e+d+c-b+a=0 \quad (\text{equ. 75})$$

$$a+c-e=\frac{1}{2} \quad (\text{equ. 76})$$

$$f-d+b=\frac{1}{2} \quad (\text{equ. 77})$$

Equation 74 guarantees unity gain. Equation 75 guarantees that the high pass filter will generate zero for a constant input signal. Equations 76 and 77 guarantee that an original signal once transferred can be reconstructed exactly.

The following equations show a single step in the inverse transformation:

$$D_2 = 2(-eH_0 - bG_0 + cH_1 + dG_1 + aH_2 - fG_2) \quad (\text{equ. 78})$$

$$D_3 = 2(fH_0 + aG_0 - dH_1 + cG_1 + bH_2 - eG_2) \quad (\text{equ. 79})$$

As for the forward filtering process, the interleaved H and G data stream is multiplied by the relevant integer numerator and summed as shown. The output D data values are found by dividing the summations by the constant 64, which is also an integer power of 2.

To calculate the first and last H and G values, the filter equations must be altered such that values outside the boundaries of the data stream are not required. For example, if H_0 is to be calculated using the six coefficient filter, the values D_1 and D_2 would be required. Because

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these values are not defined, a different filter is used at the beginning and end of the data stream. The new filters are determined such that the reconstruction process for the first and last two data values is possible. The following 5 pair of equations show the filter used to calculate the first H and G values:

$$H_0 = cD_0 - dD_1 - eD_2 + fD_3 \quad (\text{equ. 80})$$

$$G_0 = dD_0 + cD_1 - bD_2 + aD_3 \quad (\text{equ. 81})$$

The last H and G values are calculated with:

$$10 \quad H_3 = aD_3 + bD_2 + cD_1 - dD_0 \quad (\text{equ. 82})$$

$$G_3 = fD_3 - eD_2 + dD_1 + cD_0 \quad (\text{equ. 83})$$

In this case, these equations are equivalent to using the non-boundary equations with data values outside the data stream being equal to zero. The following inverse 15 transform boundary filters are used to reconstruct the first two and last two data values:

$$D_0 = 2 \left(\left(c - \frac{b}{\beta} \right) H_0 + \left(d + \frac{e}{\beta} \right) G_0 + aH_1 - fG_1 \right) \quad (\text{equ. 84})$$

$$D_1 = 2 \left(\left(\frac{a}{\beta} - d \right) H_0 + \left(c - \frac{f}{\beta} \right) G_0 + bH_1 - eG_1 \right) \quad (\text{equ. 85})$$

$$D_A = 2 \left(-eH_A - bG_A + \left(c - \frac{f}{\beta} \right) H_3 + \left(d - \frac{a}{\beta} \right) G_3 \right) \quad (\text{equ. 86})$$

$$D_B = 2 \left(fH_A + aG_A - \left(d + \frac{e}{\beta} \right) H_3 + \left(c - \frac{b}{\beta} \right) G_3 \right) \quad (\text{equ. 87})$$

INCREASING SOFTWARE DECOMPRESSION SPEED

A system is desired for compressing and decompressing video using dedicated digital hardware to compress and 20 using software to decompress. For example, in a video mail application one user uses a hardware compression expansion card for an IBM PC personal computer coupled to a video camera to record a video message in the form of a video message file. This compressed video message file is then 25 transmitted via electronic mail over a network such as a hardwired network of an office building. A recipient user receives the compressed video message file as he/she would receive a normal mail file and then uses the software to

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decompress the compressed video message file to retrieve the video mail. The video mail may be displayed on the monitor of the recipient's personal computer. It is desirable to be able to decompress in software because
5 decompressing in software frees multiple recipients from purchasing relatively expensive hardware. Software for performing the decompression may, for example, be distributed free of charge to reduce the cost of the composite system.

10 In one prior art system, the Intel Indeo video compression system, a hardware compression expansion card compresses video and a software package is usable to decompress the compressed video. This system, however, only achieves a small compression ratio. Accordingly,
15 video picture quality will not be able to be improved as standard personal computers increase in computing power and/or video bandwidth.

The specification above discloses a method and apparatus for compressing and decompressing video. The
20 software decompression implementation written in the programming language C disclosed in Appendix A only decompresses at a few frames per second on a standard personal computer at the present date. A method capable of implementation in software which realizes faster
25 decompression is therefore desirable.

A method for decompressing video described above is therefore modified to increase software execution speed. Although the $b=19/32$, $a=11/32$, $c=5/32$ and $d=3/32$ coefficients used to realize the high and low pass forward
30 transform perfect reconstruction digital filters are used by dedicated hardware to compress in accordance with an above described method, the coefficients $b=5/8$, $a=3/8$, $c=1/8$ and $d=1/8$ are used to decompress in software on a digital computer. The coefficients are determined as shown
35 in the table below.

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$$\begin{aligned}
 a &= \frac{1+\sqrt{3}}{8} \approx .3415(8) = 2.732 \approx \frac{3}{8} \\
 b &= \frac{3+\sqrt{3}}{8} \approx .5915(8) = 4.732 \approx \frac{5}{8} \\
 c &= \frac{3-\sqrt{3}}{8} \approx .1585(8) = 1.268 \approx \frac{1}{8} \\
 d &= \frac{-1+\sqrt{3}}{8} \approx .0915(8) = 0.732 \approx \frac{1}{8}
 \end{aligned}$$

5

Table 5

An even start inverse transform digital filter in accordance with the present embodiment is:

$$D_0 = 4[(b-a)H_0 + (c-d)G_0] \quad (\text{equ. 88})$$

where, for example, D_0 is a first inverse transformed data value indicative of a corresponding first data value of a row of the original image, and where H_0 and G_0 are first low and high pass component transformed data values of a row of a sub-band decomposition.

An odd end inverse transform digital filter in accordance with the present embodiment is:

$$D_8 = 4[(c+d)H_8 - (a+b)G_8] \quad (\text{equ. 89})$$

where, for example, D_8 is a last inverse transformed data value indicative of a corresponding last data value of a row of the original image, and where H_8 and G_8 are last low and high pass component transformed data values of a row of a sub-band decomposition.

An odd interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x-1)}{2} = \frac{1}{8}H(x-1) - \frac{5}{8}G(x-1) + \frac{3}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 90})$$

25 An even interleaved inverse transform digital filter in accordance with the present embodiment is:

$$\frac{D(2x)}{2} = -\frac{1}{8}H(x-1) + \frac{1}{8}G(x-1) + \frac{5}{8}H(x) + \frac{1}{8}G(x) \quad (\text{equ. 91})$$

As indicated by equations 90 and 91, the odd and even interleaved inverse transform digital filters operable on

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the same H and G values of the sub-band decomposition but generate the odd and even inverse transformed data values in a row between the even start and odd end filters of equations 88 and 89.

- 5 Using the above even start, odd end, odd interleaved and even interleaved inverse transform digital filters, a frame rate of approximately 15 frames/second is realizable executing on a Macintosh Quadra personal computer having a 68040 microprocessor. Digital filters using the
- 10 coefficients $b=5/8$, $a=3/8$, $c=1/8$ and $d=1/8$ may also be realized in dedicated digital hardware to reduce the cost of a dedicated hardware implementation where a slightly lower compression ratio is acceptable.

- To further increase software decompression speed when
- 15 decompressing video on a digital computer, only two octaves of inverse transform are performed on video which was previously compressed using three octaves of forward transform. This results in the low pass component of the octave 0 decomposition. The low pass component of the
- 20 octave 0 decomposition is a non-aliased high quality quarter size decimated version of the original image. Rather than performing octave 0 of inverse transform, horizontal linear interpolation is used to expand each row of data values of the low pass component of the octave 0
- 25 decomposition into twice the number of data values. To expand the number of rows, each row of interpolated data values is replicated once so that the total number of rows is doubled. In some embodiments, interpolation techniques other than linear interpolation are used to improve image
- 30 quality. For example, spline interpolation or polynomial interpolation may be used.

- To further increase software execution speed when decompressing video, luminance data values are decompressed using the digital filters of equations 88, 89, 90 and 91.
- 35 The chrominance data values, on the other hand, are decompressed using even and odd interleaved reconstruction filters having a fewer number of coefficients than four.

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In one embodiments, two coefficient odd interleaved Haar and even interleaved Haar filters are used. The even interleaved Haar reconstruction filter is:

$$D_0 = (H_0 + G_0) \quad (\text{equ. 92})$$

5 The odd interleaved Haar reconstruction filter is:

$$D_1 = (H_0 - G_0) \quad (\text{equ. 93})$$

Because the above Haar filters each only have two coefficients, there is no boundary problem as is addressed in connection with an above-described method. Accordingly,
10 another start inverse transform digital filter and another end inverse transform digital filter are not used.

To increase software execution speed still further when decompressing video, variable-length SEND and STILL_SEND tokens are used. Data values are encoded using
15 a Huffman code as disclosed above whereas tokens are generated in variable-length form and appear in this variable-length form in the compressed data stream. This allows decompression to be performed without first calculating flags.

20 Figure 44 shows variable-length tokens used for encoding and decoding in accordance with some embodiments of the present invention. Because transitions from SEND mode to STOP mode or from STILL_SEND mode to STOP mode occur most frequently of the transitions indicated in
25 Figure 44, the corresponding tokens consist of only one bit.

In general, if an area changes from white to black in two consecutive frames of a video sequence and if the encoder is in LPF_SEND mode, then the difference between
30 the corresponding data values after quantization will be much larger than 37. 37 is the maximum number encodable using the specific Huffman code set forth in connection with an above-described method. Because such a large

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change in data value cannot be encoded, an artifact will be generated in the decompressed image for any change in quantized data values exceeding 37. Accordingly, the Huffman code in the table below is used in accordance with one embodiment of the present invention.

	HUFFMAN CODE	qindex
	0	0
	1s1	±1
	1s01	±2
10	1s001	±3
	1s0001	±4
	1s00001	±5
	1s000001	±6
	1s0000001	±7
15	1s0000000 (qindex -8)	±8 . . ±135

Table 6

In Table 6 above, the value ($|qindex| - 8$) is seven bits in length. The s in Table 6 above is a sign bit.

This embodiment is not limited to video mail applications and is not limited to systems using dedicated hardware to compress and software executing on a digital computer to decompress. Digital circuitry of a general purpose digital computer having a microprocessor may be used to decode and inverse transform a compressed image data stream. The coefficients $5/8$, $3/8$, $1/8$ and $1/8$ independent of sign may be the four coefficients of four coefficient high and low pass forward transform perfect reconstruction digital filters used to transform image data values into a sub-band decomposition.

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Although the present invention has been described by way of the above described specific embodiments, it will be understood that certain adaptations, modifications, rearrangements and combinations of various features of the specific embodiments may be practiced without departing from the scope of the invention. Filters other than the four coefficient quasi-Daubechies filters can be used. In some embodiments, six coefficient quasi-Daubechies filters are used. Embodiments of this invention may, for example, be practiced using a one-dimensional tree structure, a two-dimensional tree structure, or a three-dimensional tree structure. Rather than testing whether or not a two-by-two block of data values is interesting, blocks of other sizes may be used. Three-by-three blocks of data values may, for example, be tested. Blocks of different sizes may be used in different octaves of a decomposition. In certain embodiments, there are different types of interesting blocks. The use of tokens in combination with use of a tree structure of a decomposition to reduce the number of data values encoded may be extended to include other tokens having other meanings. The "interesting with motion" token is but one example. Tree structures may be used in numerous ways to estimate the activity of a frame for rate control purposes. Numerous boundary filters, thresholds, encoder and decoder modes, token schemes, tree traversing address generators, quantization schemes, Huffman-like codes, and rate control schemes will be apparent from the specific embodiments. The above-described specific embodiments are therefore described for instructional purposes only and are not intended to limit the invention as set forth in the appended claims.

DATA COMPRESSION AND DECOMPRESSION
GREGORY KNOWLES AND ADRIAN S. LEWIS
M-2357 US
APPENDIX A

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source/Bits.c

```

/*
    Reading and writing bits from a file
*/

#include    "../include/xwave.h"
#include    "../include/Bits.h"

Bits  bopen(name,mode)

String name, mode;

{
    Bits  bits=(Bits)MALLOC(sizeof(BitsRec));

    if((bits->fp=fopen(name,mode))==(FILE*)0)Eprintf("Failed to open binary
file\n");    /*change*/
    bits->bufsize=0;    /*new*/
    bits->buf=(unsigned char)0;    /*new*/
    return(bits);
}

void  bclose(bits)

Bits  bits;

{
    if(fclos(bits->fp)!=0) Eprintf("Failed to close binary file\n"); /*was:
fclos(bits->fp)*/

```

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```

    XtFree(bits);
}

void bread(bytes,num,bits)

unsigned char    *bytes;
int    num;
Bits    bits;

{
    int    byte=0, bit=0,pull,b;

    bytes[byte]=0;
    while(num>0) {
        if (bits->bufsize==0) {
            pull=fgetc(bits->fp);
            if(pull==EOF)
            {
                /*printf("EOF\n");  Previously didn't check for
EOF:bits->buf=(unsigned char)fgetc(bits->fp)*/
                for(b=byte+1;b<num/8+1;b++)
                    bytes[b]=(unsigned char)0;
                return;
            }
            bits->buf=(unsigned char)pull;
            bits->bufsize=8;
        }

        bytes[byte]=((1&bits->buf)!=0)?bytes[byte]|(1<<bit):bytes[byte]&~(1<<bit);
        if (bit==7) { bit=0; byte++; bytes[byte]=0; } /* was bit==8 */
        else bit++;
        bits->buf=bits->buf>>1;
    }
}

```

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```
        bits->bufsize--;  
        num--;  
    }  
}  
  
void bwrite(bytes,num,bits)  
  
unsigned char    *bytes;  
int    num;  
Bits    bits;  
  
{  
    int    byte=0, bit=0;  
    unsigned char    xfer;  
  
    while(num>0) {  
        if (bit==0) {  
            xfer=bytes[byte++];
```

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source/Color.c

```
/*
 *   Color routines
 */

#include    "../include/xwave.h"
#define    GAMMA    1.0/2.2

int
VisualClass[6] = {PseudoColor, DirectColor, TrueColor, StaticColor, GrayScale, StaticGray};

/*   Function Name:    Range
 *   Description:    Range convert for RGB/YUV calculations
 *   Arguments:    old_x - old value (0..old_r-1)
 *                old_r - old range < new_r
 *                new_r - new range
 *   Returns:    old_x scaled up to new range
 */

int    Range(old_x, old_r, new_r)

int    old_x, old_r, new_r;

{
    return((old_x*new_r)/old_r);
}

/*   Function Name:    Gamma
 *   Description:    Range convert with Gamma correction for RGB/YUV calculations
 *   Arguments:    as Range +
 *                factor - gamma correction factor
```

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* Returns: old_x gamma corrected and scaled up to new range

*/

```
int Gamma(old_x,old_r,new_r,factor)
```

```
int old_x, old_r, new_r;
```

```
double factor;
```

```
{
```

```
    return((int)((double)new_r*pow((double)old_x/(double)old_r,factor)));
```

```
}
```

/* Function Name: Dither

* Description: Range convert with dithering for RGB/YUV calculations

* Arguments: levels - output range (0..levels-1)

* pixel - pixel value (0..1 < < 8+precision-1)

* x, y - dither location

* precision - pixel range (0..1 < < 8+precision-1)

* Returns: dithered value (0..levels-1)

*/

```
int Dither(levels,pixel,x,y,precision)
```

```
int pixel, levels, x, y, precision;
```

```
{
```

```
    int bits=8+precision,
```

```
        pixlev=pixel*levels,
```

```
value=(pixlev >> bits)+((pixlev-(pixlev&(-1 << bits)))>>precision>global->dither[x
&15][y&15]?1:0);
```

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```

return(value >= levels?levels-1:value);
}

/*  Function Name:      ColCvt
 *  Description:  Converts between RGB and YUV triples
 *  Arguments:   src - source triple
 *               dst - destination triple
 *               rgb_yuv - convert direction RGB->YUV True
 *               max - range of data (max-1...-max)
 *  Returns:     alters dst.
 */

```

```
void ColCvt(src,dst,rgb_yuv,max)
```

```
short src[3], dst[3];
```

```
Boolean rgb_yuv;
```

```
int max;
```

```

{
    double    rgb_yuv_mat[2][3][3]={
        {0.299,0.587,0.114},
        {-0.169,-0.3316,0.5},
        {0.5,-0.4186,-0.0813}
    },{
        {1,0,1.4021},
        {1,-0.3441,-0.7142},
        {1,1.7718,0}
    }
};

int i, channel;

for(channel=0;channel<3;channel++) {

```

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```

double      sum=0.0;

    for(i=0;i<3;i++)
sum +=(double)(src[i])*rgb_yuv_mat[rgb_yuv?0:1][channel][i];
    dst[channel]=(int)sum < -max?-max:(int)sum > max-1?max-1:(short)sum;
}
}

```

```

/*      Function Name:      CompositePixel
*      Description:  Calculates pixel value from components
*      Arguments:   frame - Frame to be drawn on
*                  x, y - coordinate of pixel in data
*                  X, Y - coordinate of pixel in display
*      Returns:     pixel value in colormap
*/

```

```
int      CompositePixel(frame,x,y,X,Y)
```

```
Frame frame;
```

```
int      x, y, X, Y;
```

```
{
```

```
    Video vid=frame->video;
```

```
    int      channel=frame->channel, pixel, value=0;
```

```
    if (channel!=3) {
```

```
        pixel=(int)vid->data[channel][frame->frame][Address2(vid,channel,x,y)]+(128<<vid-
        >precision);
```

```
        value=Dither(global->levels,pixel,X,Y,vid->precision);
```

```
    } else for(channel=0;channel<3;channel++) {
```

```
        int
```


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```
levels=vid->type == RGB?global->rgb_levels:global->yuv_levels[channel];
```

```
pixel=(int)vid->data[channel][frame->frame][Address(vid,channel,x,y)]+(128<<vid->precision),
```

```
value=levels*value+Dither(levels,pixel,X,Y,vid->precision);
```

```
}
```

```
return(value);
```

```
}
```

```
void InitVisual()
```

```
{
```

```
Display *dpy=XtDisplay(global->toplevel);
```

```
int scrn=XDefaultScreen(dpy), class=0, depth=8, map, i, r, g, b, y, u, v;
```

```
String
```

```
VisualNames[6]={"PseudoColor","DirectColor","TrueColor","StaticColor","GrayScale",  
"StaticGray"};
```

```
XColor color;
```

```
global->visinfo=(XVisualInfo *)MALLOC(sizeof(XVisualInfo));
```

```
while(depth>0
```

```
&&!XMatchVisualInfo(dpy,scrn,depth,VisualClass[class],global->visinfo))
```

```
if (class==5) {class=0; depth--;} else class++;
```

```
Dprintf("Visual: %s depth %d\n",VisualNames[class],depth);
```

```
global->palettes=(Palette)MALLOC(sizeof(PaletteRec));
```

```
strcpy(global->palettes->name,"Normal");
```

```
global->palettes->next=NULL;
```

```
global->no_pals=1;
```

```
switch(global->visinfo->class) {
```

```
case TrueColor:
```

```
case DirectColor:
```

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```

case StaticColor:
case GrayScale:
    fprintf(stderr, "Unsupported visual type: %s\n", VisualNames[class]);
    exit();
    break;
case PseudoColor:
    global->levels=global->visinfo->colormap_size;
    global->rgb_levels=(int)pow((double)global->levels,1.0/3.0);
    for(map=0;map<2;map++) { /* rgb non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(r=0;r<global->rgb_levels;r++)
            for(g=0;g<global->rgb_levels;g++)
                for(b=0;b<global->rgb_levels;b++) {

color.pixel=(r*global->rgb_levels+g)*global->rgb_levels+b;

color.red=(map&1)?Gamma(r,global->rgb_levels,65536,GAMMA):Range(r,global->rg
b_levels,65536);

color.green=(map&1)?Gamma(g,global->rgb_levels,65536,GAMMA):Range(g,global->
rgb_levels,65536);

color.blue=(map&1)?Gamma(b,global->rgb_levels,65536,GAMMA):Range(b,global->r
gb_levels,65536);

color.flags=DoRed | DoGreen | DoBlue;

XStoreColor(dpy,global->cmaps[map],&color);

        }

color.pixel=global->levels-1;
color.red=255<<8;

```

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```

        color.green=255 < < 8;
        color.blue=255 < < 8;
        color.flags=DoRed | DoGreen | DoBlue;
        XStoreColor(dpy,global->cmaps[map],&color);
    }
    for(map=2;map<4;map++) { /* mono non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(i=0;i<global->visinfo->colormap_size;i++) {
            color.pixel=i;

color.red=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,6
5536);

color.green=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels
,65536);

color.blue=(map&1)?Gamma(i,global->levels,65536,GAMMA):Range(i,global->levels,
65536);

            color.flags=DoRed | DoGreen | DoBlue;
            XStoreColor(dpy,global->cmaps[map],&color);
        }
    }

    global->yuv_levels[0]=(int)pow(((double)global->levels,1.0/2.0);
    global->yuv_levels[1]=(int)pow(((double)global->levels,1.0/4.0);
    global->yuv_levels[2]=(int)pow(((double)global->levels,1.0/4.0);
    for(map=4;map<6;map++) { /* yuv non-gamma and gamma maps */

global->cmaps[map]=XCreateColormap(dpy,XDefaultRootWindow(dpy),global->visinfo
->visual,AllocAll);

        for(y=0;y<global->yuv_levels[0];y++)

```

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```

        for(u=0;u < global->yuv_levels[1];u++)
            for(v=0;v < global->yuv_levels[2];v++) {
                short
src[3] = {(short)(Range(y,global->yuv_levels[0],65536)-32768),

(short)(Range(u,global->yuv_levels[1],65536)-32768),

(short)(Range(v,global->yuv_levels[2],65536)-32768)}, dst[3];

                ColCvt(src,dst,False,65536/2);

color.pixel=(y*global->yuv_levels[1]+u)*global->yuv_levels[2]+v;

color.red=(map&1)?Gamma((int)dst[0]+32768,65536,65536,GAMMA):(int)dst[0]+32768;

color.green=(map&1)?Gamma((int)dst[1]+32768,65536,65536,GAMMA):(int)dst[1]+32768;

color.blue=(map&1)?Gamma((int)dst[2]+32768,65536,65536,GAMMA):(int)dst[2]+32768;

                color.flags=DoRed | DoGreen | DoBlue;

XStoreColor(dpy,global->cmaps[map],&color);

            }

color.pixel=global->levels-1;
color.red=255<<8;
color.green=255<<8;
color.blue=255<<8;
color.flags=DoRed | DoGreen | DoBlue;
XStoreColor(dpy,global->cmaps[map],&color);
    }

```

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```

    global->palettes->mappings=NULL;
    break;
case StaticGray:
    global->levels=1 << depth;
    for(i=0;i<6;i++) global->cmaps[i]=XDefaultColormap(dpy,scrn);
    color.pixel=0;
    XQueryColor(dpy,XDefaultColormap(dpy,scrn),&color);
    if (color.red==0 && color.green==0 && color.blue==0)
global->palettes->mappings=NULL;
    else {
        global->palettes->mappings=(Map)MALLOC(sizeof(MapRec));
        global->palettes->mappings->start=0;
        global->palettes->mappings->finish=global->levels-1;
        global->palettes->mappings->m=-1;
        global->palettes->mappings->c=global->levels-1;
        global->palettes->mappings->next=NULL;
    }
    break;
}
}

```

Colormap ChannelCmap(channel,type,gamma)

int channel;

VideoFormat type;

Boolean gamma;

{

Colormap cmap;

if (channel!=3 || type==MONO) {

if (gamma) cmap=global->cmaps[global->cmaps[2]==NULL?3:2];

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```
        else cmap=global->cmaps[global->cmaps[3]==NULL?2:3];
    } else if (type==RGB) {
        if (gamma) cmap=global->cmaps[global->cmaps[0]==NULL?1:0];
        else cmap=global->cmaps[global->cmaps[1]==NULL?0:1];
    } else {
        if (gamma) cmap=global->cmaps[global->cmaps[4]==NULL?5:4];
        else cmap=global->cmaps[global->cmaps[5]==NULL?4:5];
    }
    return(cmap);
}
```

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source/Convert.c

```
#include    "../include/xwave.h"

short  cti(c)

char  c;

{
    return((short)(c)^-128);
}

char  itc(i)

short  i;

{
    static int    errors=0;
    if (i < -128 || i > 127) {
        if (errors == 99) {
            Dprintf("100 Conversion overflows\n");
            errors=0;
        } else errors++;
        i=(i < -128)?-128:127;
    }
    return((char)(i^128));
}
```

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source/Convolve3.c

```

/*
    2D wavelet transform convolver (fast hardware emulation)
    New improved wavelet coeffs : 11 19 5 3
*/

#include    "../include/xwave.h"

/*    Function Name:    Round
    *    Description:    Rounding to a fixed number of bits, magnitude rounded down
    *    Arguments:    number - number to be rounded
    *                   bits - shifted bits lost from number
    *    Returns:    rounded number
    */

short Round(number,bits)

int    number;
int    bits;

{
    if (bits == 0) return((short)number);
    else return((short)(number + (1 < < bits-1) - (number < 0 ? 0 : 1) > > bits));
}

/*    Function Name:    Convolve
    *    Description:    Perform a wavelet convolution on image data
    *    Arguments:    data - data to be transformed
    *                   dirn - convolution direction

```


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```

*           size - size of image data
*           oct_src, oct_dst - initial and final octave numbers
*   Returns:   data altered
*/

```

```
void Convolve(data,dirn,size,oct_src,oct_dst)
```

```
short *data;
```

```
Boolean   dirn;
```

```
int   size[2], oct_src, oct_dst;
```

```
{
```

```
    int   tab[4][4], addr[4]={-1,-1,-1,-1}, index, mode, i, j, oct, orient,
area=size[0]*size[1];
```

```
    Boolean   fwd_rev=oct_src<oct_dst;
```

```
    int   windows[12][5]={
        {1,2,3,-4,2}, /* 0 - normal forward 0 */
        {4,-3,2,1,3}, /* 1 - normal forward 1 */
        {1,-2,3,4,2}, /* 2 - normal reverse 0 */
        {4,3,2,-1,3}, /* 3 - normal reverse 1 */
        {2,3,4,-4,3}, /* 4 - end forward 0 */
        {4,-4,3,2,4}, /* 5 - end forward 1 */
        {2,2,3,-4,2}, /* 6 - start forward 0 */
        {4,-3,2,2,3}, /* 7 - start forward 1 */
        {3,-4,-4,3,4}, /* 8 - break reverse end dirn==False*/
        {4,3,-3,-4,3}, /* 9 - break reverse start dirn==False */
        {-3,-4,4,3,4}, /* 10 - break reverse end dirn==True */
        {-4,3,3,-4,3}, /* 11 - break reverse start dirn==True */
    }, win[3];           /* 12 - no calculation */
```

```
    for(oct=oct_src;oct!=oct_dst;oct+=(fwd_rev?1:-1)) {
```

```
        long   shift=oct-(fwd_rev?0:1);
```

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```

for(orient=0;orient<2;orient++) {
    Boolean    x_y=fwd_rev==(orient==0);

    for (index=0;index<(area>>(shift<<1));index++) {
        long    major, minor, value, valuex3, valuex11, valuex19, valuex5;

        major=index/(size[x_y?0:1]>>shift);
        minor=index-major*(size[x_y?0:1]>>shift);
        for(j=0;j<3;j++) win[j]=12;
        switch(minor) {
            case 0: break;
            case 1: if (!fwd_rev) win[0]=dirn?11:9; break;
            case 2: if (fwd_rev) { win[0]=6; win[1]=7; }; break;
            default:
                if (minor+1==size[x_y?0:1]>>shift) {
                    if (fwd_rev) { win[0]=4; win[1]=5; }
                    else { win[0]=2; win[1]=3; win[2]=dirn?10:8; }
                } else if (fwd_rev) {
                    if ((1&minor)==0) { win[0]=0; win[1]=1; }
                } else {
                    if ((1&minor)!=0) { win[0]=2; win[1]=3; }
                }
            }
        }

        addr[3&index]=(x_y?minor:major)+size[0]*(x_y?major:minor)<<shift;
        value=(int)data[addr[3&index]];

        valuex5=value+(value<<2);
        valuex3=value+(value<<1);
        valuex11=valuex3+(value<<3);
        valuex19=valuex3+(value<<4);
        tab[3&index][3]=fwd_rev || !dirn?valuex3:valuex19;
        tab[3&index][2]=fwd_rev || dirn?valuex5:valuex11;
    }
}

```

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```

    tab[3&index][1]=fwd_rev || !dirn?valuex19:valuex3;
    tab[3&index][0]=fwd_rev || dirn?valuex11:valuex5;
    for(j=0;j<3 && win[j]!=12;j++) {
        int    conv=0;

        for(i=0;i<4;i++) {
            int    wave=dirn?3-i:i;

            conv += negif(0>windows[win[j]][wave],tab[3&index+abs(windows[win[j]][i])][wave]);
        }

        data[addr[3&index+windows[win[j]][4]]]=Round(conv,fwd_rev?5:win[j]>7?3:4);
    }
}
}
}
}

```

source/Copy.c

/*

Copy video, includes direct copy, differencing, LPF zero, LPF only, RGB-YUV
conversion and gamma correction

*/

#include "../include/xwave.h"

#include "Copy.h"

extern int Shift();

extern void ColCvt();

void CopyVideoCtrl(w,closure,call_data)

Widget w;

caddr_t closure, call_data;

{

CopyCtrl ctrl=(CopyCtrl)closure;

Video new=CopyHeader(ctrl->video), src=ctrl->video;

int frame, channel, i, x, y, X, Y, map[256];

if (global->batch == NULL)

ctrl->mode=(int)XawToggleGetCurrent(ctrl->radioGroup);

strcpy(new->name,ctrl->name);

strcpy(new->files,new->name);

switch(ctrl->mode) {

case 1: Dprintf("Direct copy\n");

new->UVsample[0]=ctrl->UVsample[0];

new->UVsample[1]=ctrl->UVsample[1];

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```

        break;
    case 2:    Dprintf("Differences\n");
        break;
    case 3:    Dprintf("LPF zero\n");
        break;
    case 4:    Dprintf("LPF only\n");
        new->trans.type = TRANS_None;

new->size[0] = new->size[0] >> new->trans.wavelet.space[0];

new->size[1] = new->size[1] >> new->trans.wavelet.space[0];
        break;
    case 5:    Dprintf("RGB-YUV\n");
        new->type = new->type == YUV?RGB:YUV;
        new->UVsample[0] = 0;
        new->UVsample[1] = 0;
        break;
    case 6:    Dprintf("Gamma conversion\n");
        new->gamma = !new->gamma;
        for(i=0;i<256;i++)
map[i] = gamma(i,256,new->gamma?0.5:2.0);
        break;
}

if (new->disk == True) SaveHeader(new);
for(frame=0;frame<new->size[2];frame++) {
    GetFrame(src,frame);
    NewFrame(new,frame);
    switch(ctrl->mode) {
        case 1:
for(channel=0;channel<(new->type == MONO?1:3);channel++) {
            int    size = Size(new,channel,0)*Size(new,channel,1);

```

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```

        for(y=0;y < Size(new,channel,1);y++)
            for(x=0;x < Size(new,channel,0);x++)

new->data[channel][frame][x+Size(new,channel,0)*y]=src->data[channel][frame][Shift(
x,src->type==YUV &&
channel!=0?new->UVsample[0]-src->UVsample[0]:0)+Size(src,channel,0)*Shift(y,src-
>type==YUV && channel!=0?new->UVsample[1]-src->UVsample[1]:0)];
    }
    break;

    case 2:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

    for(i=0;i < size;i++)
new->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[ch
annel][frame-1][i]);
    }
    break;

    case 3:
for(channel=0;channel < (new->type==MONO?1:3);channel++) {
    int
size=Size(new,channel,0)*Size(new,channel,1);

    for(i=0;i < size;i++) {
        x=i%Size(new,channel,0);
y=i/Size(new,channel,0);

        if
(x%(1 < < new->trans.wavelet.space[new->type==YUV && channel!=0?1:0])==0
&& y%(1 < < new->trans.wavelet.space[new->type==YUV &&
channel!=0?1:0])==0)

```

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```
new->data[channel][frame][i]=0;
```

```
else
```

```
new->data[channel][frame][i]=src->data[channel][frame][i];
```

```
}
```

```
}
```

```
break;
```

```
case 4:
```

```
for(channel=0;channel<(new->type==MONO?1:3);channel++) {
```

```
int
```

```
size=Size(new,channel,0)*Size(new,channel,1);
```

```
for(i=0;i<size;i++) {
```

```
x=i%Size(new,channel,0);
```

```
y=i/Size(new,channel,0);
```

```
new->data[channel][frame][i]=src->data[channel][frame][(x+(y<<new->trans.wavele  
t.space[0])*Size(new,channel,0))<<new->trans.wavelet.space[0]];
```

```
}
```

```
}
```

```
break;
```

```
case 5: for(X=0;X<new->size[0];X++)
```

```
for(Y=0;Y<new->size[1];Y++) {
```

```
short src_triple[3], dst_triple[3];
```

```
for(channel=0;channel<3;channel++)
```

```
src_triple[channel]=src->data[channel][frame][Address(src,channel,X,Y)];
```

```
ColCvt(src_triple,dst_triple,new->type==YUV,1<<7+new->precision);
```

```
for(channel=0;channel<3;channel++)
```

```
new->data[channel][frame][Address(new,channel,X,Y)]=dst_triple[channel];
```

```
}
```

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```

        break;

        case 6:
            for(channel=0;channel < (new->type == MONO?1:3);channel++) {
                int
                size = Size(new,channel,0)*Size(new,channel,1);

                for(i=0;i < size;i++)
                    new->data[channel][frame][i] = map[src->data[channel][frame][i]+128]-128;
            }
            break;
        }

        if (frame > 0) FreeFrame(src,frame-1);
        SaveFrame(new,frame);
        FreeFrame(new,frame);
    }
    FreeFrame(src,src->size[2]-1);
    new->next = global->videos;
    global->videos = new;
}

void BatchCopyCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CopyCtrl  ctrl=(CopyCtrl)closure;

    if (ctrl->video == NULL)
        ctrl->video = FindVideo(ctrl->src_name,global->videos);
    CopyVideoCtrl(w,closure,call_data);
}

```


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```
CopyCtrl    InitCopyCtrl(name)
```

```
String name;
```

```
{
    CopyCtrl    ctrl=(CopyCtrl)MALLOC(sizeof(CopyCtrlRec));

    strcpy(ctrl->src_name,name);
    strcpy(ctrl->name,name);
    ctrl->mode=1;
    return(ctrl);
}
```

```
#define      COPY_ICONS      17
```

```
void CopyVideo(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
    Video video=(Video)closure;
    CopyCtrl    ctrl=InitCopyCtrl(video->name);
    NumInput    UVinputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    Message      msg=NewMessage(ctrl->name,NAME_LEN);
    XtCallbackRec    destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)UVinputs},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Widget      shell=ShellWidget("copy_video",w,SW_below,NULL,destroy_call),
```

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```

        form = FormatWidget("cpy_form",shell), widgets[COPY_ICONS];
FormItem    items[] = {
    {"cpy_cancel", "cancel", 0, 0, FW_icon, NULL},
    {"cpy_confirm", "confirm", 1, 0, FW_icon, NULL},
    {"cpy_title", "Copy a video", 2, 0, FW_label, NULL},
    {"cpy_vid_lab", "Video Name:", 0, 3, FW_label, NULL},
    {"cpy_text", NULL, 4, 3, FW_text, (String)msg},

    {"cpy_copy", "copy", 0, 5, FW_toggle, NULL},
    {"cpy_diff", "diff", 6, 5, FW_toggle, (String)6},
    {"cpy_lpf_zero", "lpf_zero", 7, 5, FW_toggle, (String)7},
    {"cpy_lpf_only", "lpf_only", 8, 5, FW_toggle, (String)8},
    {"cpy_color", "color_space", 9, 5, FW_toggle, (String)9},

    {"cpy_gamma", "gamma", 10, 5, FW_toggle, (String)10},
    {"cpy_UV0_int", NULL, 0, 6, FW_integer, (String)&UVinputs[0]},
    {"cpy_UV0_down", NULL, 12, 6, FW_down, (String)&UVinputs[0]},
    {"cpy_UV0_up", NULL, 13, 6, FW_up, (String)&UVinputs[0]},
    {"cpy_UV1_int", NULL, 0, 14, FW_integer, (String)&UVinputs[1]},

    {"cpy_UV1_down", NULL, 12, 14, FW_down, (String)&UVinputs[1]},
    {"cpy_UV1_up", NULL, 16, 14, FW_up, (String)&UVinputs[1]},
};

XtCallbackRec    callbacks[] = {
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {CopyVideoCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {NULL, NULL}, {NULL, NULL}, {NULL, NULL}, {NULL, NULL},
    {NULL, NULL}, {NULL, NULL},
    {NumIncDec, (caddr_t)&UVinputs[0]}, {NULL, NULL},

```

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```

        {NumIncDec,(caddr_t)&UVinputs[0]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
        {NumIncDec,(caddr_t)&UVinputs[1]}, {NULL,NULL},
    };

    Dprintf("CopyVideo\n");

    msg->rows=1; msg->cols=NAME_LEN;
    ctrl->video=video;
    UVinputs[0].format="UV sub-sample X: %d";
    UVinputs[0].min=0;
    UVinputs[0].max=2;
    UVinputs[0].value= &ctrl->UVsample[0];
    UVinputs[1].format="UV sub-sample Y: %d";
    UVinputs[1].min=0;
    UVinputs[1].max=2;
    UVinputs[1].value= &ctrl->UVsample[1];

    ctrl->UVsample[0]=video->UVsample[0];
    ctrl->UVsample[1]=video->UVsample[1];
    FillForm(form,COPY_ICONS,items,widgets,callbacks);
    ctrl->radioGroup=widgets[5];
    XtSetSensitive(widgets[6],video->size[2]>1);
    XtSetSensitive(widgets[7],video->trans.type!=TRANS_None);
    XtSetSensitive(widgets[8],video->trans.type!=TRANS_None);
    XtSetSensitive(widgets[9],video->type!=MONO);
    XtSetSensitive(widgets[10],video->type!=YUV &&
video->trans.type==TRANS_None);
    XtPopup(shell,XtGrabExclusive);
};

```

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source/Frame.c

```

/*
    Frame callback routines for Destroy
*/

#include    "../include/xwave.h"
#include    <X11/Xmu/SysUtil.h>
#include    <pwd.h>
extern void CvtIndex();
extern Palette FindPalette();
extern void SetSensitive();

typedef    struct {
    Frame frame;
    int    frame_number, frame_zoom, frame_palette, frame_channel;
} ExamCtrlRec, *ExamCtrl;

void FrameDestroy(w, closure, call_data)

Widget    w;
caddr_t    closure, call_data;

{
    Frame frame=(Frame)closure;
    void CleanUpPoints(), FrameDelete();

    Dprintf("FrameDestroy\n");
    frame->point->usage--;
    if (frame->msg!=NULL) {

```

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```
        frame->msg->shell=NULL;
        CloseMessage(NULL,(caddr_t)frame->msg,NULL);
    }
    if (frame->point->usage==0) CleanUpPoints(&global->points);
    XtPopdown(frame->shell);
    XtDestroyWidget(frame->shell);
    FrameDelete(&global->frames,frame);
}
```

```
void CleanUpPoints(points)
```

```
Point *points;
```

```
{
    Point dummy=*points;

    if (dummy!=NULL) {
        if (dummy->usage<1) {
            *points=dummy->next;
            XtFree(dummy);
            CleanUpPoints(points);
        } else CleanUpPoints(&((*points)->next));
    };
}
```

```
void FrameDelete(frames,frame)
```

```
Frame *frames, frame;
```

```
{
    if (*frames!=NULL) {
        if (*frames==frame) {
```

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```

        int    number = frame->frame;

        frame->frame = -1;
        FreeFrame(frame->video, number);
        *frames = frame->next;
        XtFree(frame);
    } else FrameDelete(&(*frames)->next, frame);
}

}

void  ExamineCtrl(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

{
    ExamCtrl  ctrl = (ExamCtrl)closure;
    Arg       args[1];

    if (ctrl->frame->frame != ctrl->frame_number-ctrl->frame->video->start) {
        int    old_frame = ctrl->frame->frame;

        ctrl->frame->frame = ctrl->frame_number-ctrl->frame->video->start;
        FreeFrame(ctrl->frame->video, old_frame);
        GetFrame(ctrl->frame->video, ctrl->frame->frame);
    }

    ctrl->frame->zoom = ctrl->frame_zoom;
    ctrl->frame->palette = ctrl->frame_palette;
    ctrl->frame->channel = ctrl->frame_channel;
    XtSetArg(args[0], XtNbixmap, UpdateImage(ctrl->frame));
    XtSetValues(ctrl->frame->image_widget, args, ONE);
}

```

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```

XtSetArg(args[0],XtNcolormap,ChannelCmap(ctrl->frame->channel,ctrl->frame->vide
o->type,ctrl->frame->video->gamma));
    XtSetValues(ctrl->frame->shell,args,ONE);
    if (ctrl->frame->msg!=NULL) UpdateInfo(ctrl->frame);
}

```

```

#define      EXAM_ICONS      13

```

```

void  Examine(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{
    ExamCtrl  ctrl=(ExamCtrl)MALLOC(sizeof(ExamCtrlRec));
    NumInput  num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    XtCallbackRec destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)num_inputs},
        {NULL,NULL},
    }, pal_call[2*global->no_pals];
    Widget      shell=ShellWidget("examine",w,SW_below,NULL,destroy_call),
               form=FormatWidget("exam_form",shell), widgets[EXAM_ICONS],
               pal_widgets[global->no_pals], pal_shell;
    Frame frame=(Frame)closure;
    FormItem  items[]={
        {"exam_cancel","cancel",0,0,FW_icon,NULL},
        {"exam_confirm","confirm",1,0,FW_icon,NULL},
        {"exam_label","Examine",2,0,FW_label,NULL},
        {"exam_ch_lab","Channel :",0,3,FW_label,NULL},
        {"exam_ch_btn",ChannelName[frame->video->type][frame->channel],4,3,FW_button,"

```

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```

exam_cng_ch"},
    {"exam_pal_lab", "Palette : ".0,4,FW_label,NULL},

{"exam_pal_btn", FindPalette(global->palettes, frame->palette)->name, 4,4,FW_button, "
exam_cng_pal"},
    {"exam_z_int", NULL, 0,6,FW_integer, (String)&num_inputs[0]},
    {"exam_z_down", NULL, 8,6,FW_down, (String)&num_inputs[0]},
    {"exam_z_up", NULL, 9,6,FW_up, (String)&num_inputs[0]},
    {"exam_zoom_int", NULL, 0,8,FW_integer, (String)&num_inputs[1]},
    {"exam_zoom_down", NULL, 8,8,FW_down, (String)&num_inputs[1]},
    {"exam_zoom_up", NULL, 12,8,FW_up, (String)&num_inputs[1]},
};

MenuItem    pal_menu[global->no_pals];
XtCallbackRec    callbacks[] = {
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {ExamineCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
};

int    i, width=0;
Palette    pal=global->palettes;
XFontStruct    *font;
Arg    args[1];
caddr_t    dummy[global->no_pals], dummy2[global->no_pals]; /*
gcc-mc68020 bug avoidance */

Dprintf("Examine\n");

```


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```

ctrl->frame = frame;
ctrl->frame_number = frame->frame + frame->video->start;
ctrl->frame_zoom = frame->zoom;
ctrl->frame_palette = frame->palette;
ctrl->frame_channel = frame->channel;
num_inputs[0].format = "Frame: %03d";
num_inputs[0].max = frame->video->start + frame->video->size[2]-1;
num_inputs[0].min = frame->video->start;
num_inputs[0].value = &ctrl->frame_number;
num_inputs[1].format = "Zoom: %d";
num_inputs[1].max = 4;
num_inputs[1].min = 0;
num_inputs[1].value = &ctrl->frame_zoom;

```

```

FillForm(form, EXAM_ICONS, items, widgets, callbacks);

```

```

font = FindFont(widgets[6]);
for(i=0; pal!=NULL; pal=pal->next, i++) {
    pal_menu[i].name = pal->name;
    pal_menu[i].widgetClass = smeBSBObjectClass;
    pal_menu[i].label = pal->name;
    pal_menu[i].hook = NULL;
    pal_call[i*2].callback = SimpleMenu;
    pal_call[i*2].closure = (caddr_t)&ctrl->frame_palette;
    pal_call[i*2+1].callback = NULL;
    pal_call[i*2+1].closure = NULL;
    width = TextWidth(width, pal->name, font);
}
pal_shell = ShellWidget("exam_cng_pal", shell, SW_menu, NULL, NULL);
FillMenu(pal_shell, global->no_pals, pal_menu, pal_widgets, pal_call);
XtSetArg(args[0], XtNwidth, 2 + width);
XtSetValues(widgets[6], args, ONE);

```

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```

if (frame->video->type == MONO) XtSetSensitive(widgets[4],False);
else {
    MenuItem    ch_menu[4];
    Widget
ch_shell=ShellWidget("exam_cng_ch",shell,SW_menu,NULL,NULL), ch_widgets[4];
    XtCallbackRec    ch_call[8];

    font=FindFont(widgets[4]);
    width=0;
    for(i=0;i<4;i++) {
        ch_menu[i].name=ChannelName[frame->video->type][i];
        ch_menu[i].widgetClass=smeBSBObjectClass;
        ch_menu[i].label=ChannelName[frame->video->type][i];
        ch_menu[i].hook=(caddr_t)&ctrl->frame_channel;
        ch_call[i*2].callback=SimpleMenu;
        ch_call[i*2].closure=(caddr_t)&ctrl->frame_channel;
        ch_call[i*2+1].callback=NULL;
        ch_call[i*2+1].closure=NULL;

width=TextWidth(width,ChannelName[frame->video->type][i],font);
    }
    FillMenu(ch_shell,4,ch_menu,ch_widgets,ch_call);
    XtSetArg(args[0],XtNwidth,2+width);
    XtSetValues(widgets[4],args,ONE);
}
XtPopup(shell,XtGrabExclusive);
}

```

```

void  FramePointYN(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

```

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```

{
    Frame frame=(Frame)closure;
    Arg args[1];
    Pixmap pixmap;
    Display *dpy=XtDisplay(global->toplevel);
    Icon point_y=FindIcon("point_y"),
        point_n=FindIcon("point_n");

    Dprintf("FramePointYN\n");
    frame->point_switch=!frame->point_switch;
    XtSetSensitive(frame->image_widget,frame->point_switch);
    XtSetArg(args[0],XtNbitmap,(frame->point_switch?point_y:point_n)->pixmap);
    XtSetValues(w,args,ONE);
    XtSetArg(args[0],XtNbitmap,&pixmap);
    XtGetValues(frame->image_widget,args,ONE);
    UpdatePoint(dpy,frame,pixmap);
    XtSetArg(args[0],XtNbitmap,pixmap);
    XtSetValues(frame->image_widget,args,ONE);
    if (frame->msg!=NULL) UpdateInfo(frame);
}

```

```

void NewPoint(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

```

```

{
    Frame frame=(Frame)closure;
    Video vid=frame->video;
    void UpdateFrames();
    int *posn=(int *)call_data,
    channel=frame->channel==3?0:frame->channel;

```

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```

posn[0]=posn[0]>>frame->zoom; posn[1]=posn[1]>>frame->zoom;
if (vid->trans.type==TRANS_Wave) {
    int    octs=vid->trans.wavelet.space[vid->type==YUV &&
channel!=0?1:0], oct;

CvtIndex(posn[0],posn[1],Size(vid,channel,0),Size(vid,channel,1),octs,&posn[0],&posn[1]
,&oct);
}
if (vid->type==YUV && channel!=0) {
    posn[0]=posn[0]<<vid->UVsample[0];
    posn[1]=posn[1]<<vid->UVsample[1];
}
Dprintf("NewPoint %d %d previous %d
%d\n",posn[0],posn[1],frame->point->location[0],frame->point->location[1]);
if (posn[0]!=frame->point->location[0] ||
posn[1]!=frame->point->location[1]) {
    UpdateFrames(global->frames,frame->point,False);
    frame->point->location[0]=posn[0];
    frame->point->location[1]=posn[1];
    UpdateFrames(global->frames,frame->point,True);
} else Dprintf("No movement\n");
}

void  UpdateFrames(frame,point,update)

Frame frame;
Point point;
Boolean    update;

{
    Arg    args[1];

```

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```

    if (frame!=NULL) {
        if (point == frame->point && frame->point_switch == True) {
            Pixmap      pixmap;
            Display      *dpy=XtDisplay(global->toplevel);

            XtSetArg(args[0],XtNbitmap,&pixmap);
            XtGetValues(frame->image_widget,args,ONE);
            UpdatePoint(dpy,frame,pixmap);
            if (update == True) {
                XtSetArg(args[0],XtNbitmap,pixmap);
                XtSetValues(frame->image_widget,args,ONE);
                if (frame->msg!=NULL) UpdateInfo(frame);
            }
        }
        UpdateFrames(frame->next,point,update);
    }
}

```

```

void CloseInfo(w,closure,call_data)

```

```

Widget      w;
caddr_t      closure, call_data;

{
    Frame frame=(Frame)closure;

    frame->msg=NULL;
}

```

```

#define      INFO_ICONS      2

```

```

void FrameInfo(w,closure,call_data)

```

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```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    Message   msg=NewMessage(NULL,1000);
    XtCallbackRec   callbacks[]={
        {SetSensitive,(caddr_t)w},
        {CloseInfo,(caddr_t)frame},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Dprintf("FrameInfo\n");
    frame->msg=msg;
    UpdateInfo(frame);
    TextSize(msg);
    MessageWindow(w,msg,frame->video->name,True,callbacks);
    XtSetSensitive(w,False);
}

```

```

void  FrameMerge(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

{
    Frame frame=(Frame)closure;
    void  MergePoints();
    Arg   args[1];

    Dprintf("FrameMerge\n");
    MergePoints(global->frames.frame);
}

```

```

    }

void MergePoints(frame_search, frame_found)

Frame frame_search, frame_found;

{
    Arg    args[1];

    if (frame_search != NULL) {
        if (NULL == XawToggleGetCurrent(frame_search->point_merge_widget)
        || frame_search == frame_found)
            MergePoints(frame_search->next, frame_found);
        else {
            Pixmap    pixmap;
            Display    *dpy = XtDisplay(global->toplevel);

            XtSetArg(args[0], XtNbitmap, &pixmap);
            XtGetValues(frame_found->image_widget, args, ONE);
            if (frame_found->point_switch == True)
                UpdatePoint(dpy, frame_found, pixmap);
            frame_search->point->usage++;
            frame_found->point->usage--;
            if (frame_found->point->usage == 0)
                CleanUpPoints(&global->points);
            frame_found->point = frame_search->point;
            if (frame_found->point_switch == True) {
                UpdatePoint(dpy, frame_found, pixmap);
                XtSetArg(args[0], XtNbitmap, pixmap);
                XtSetValues(frame_found->image_widget, args, ONE);
            }
            if (frame_found->msg != NULL) UpdateInfo(frame_found);
        }
    }
}

```

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```

        XawToggleUnsetCurrent(frame_search->point_merge_widget);
        XawToggleUnsetCurrent(frame_found->point_merge_widget);
    }
}

```

```

#define      POST_DIR      "postscript"

```

```

void  PostScript(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{
    Frame frame=(Frame)closure;
    Video video=frame->video;
    FILE *fp, *fopen();
    char  file_name[STRLEN], hostname[STRLEN];
    int    x, y, width=Size(video,frame->channel,0),
height=Size(video,frame->channel,1);
    struct passwd *pswd;
    long  clock;

    Dprintf("PostScript\n");
    sprintf(file_name,"%s%s/%s.ps\0",global->home,POST_DIR,video->name);
    fp=fopen(file_name,"w");
    fprintf(fp,"% %!PS-Adobe-1.0\n");
    pswd = getpwuid (getuid ());
    (void) XmuGetHostname (hostname, sizeof hostname);
    fprintf(fp,"% % % %Creator: %s:%s (%s)\n", hostname,pswd->pw_name,
pswd->pw_gecos);
    fprintf(fp,"% % % %Title: %s\n",video->name);

```


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```

fprintf(fp, " % % % %BoundingBox: 0 0 %d %d\n", width, height);
fprintf(fp, " % % % %CreationDate: %s", (time (&clock), ctime (&clock)));
fprintf(fp, " % % % %EndComments\n");
fprintf(fp, "%d %d scale\n", width, height);
fprintf(fp, "%d %d 8 image_print\n", width, height);
GetFrame(video, frame-> frame);
for(y=0; y < height; y++) {
    for(x=0; x < width; x++) {
        int    X, Y, oct, data;

        if (video-> trans.type == TRANS_Wave) {

CvtIndex(x, y, width, height, video-> trans.wavelet.space[0], &X, &Y, &oct);

data=128+Round(video-> data[frame-> channel%3][frame-> frame][Y*video-> size[0] +
X]*(oct==video-> trans.wavelet.space[0]?1:4), video-> precision);
        } else
data=128+Round(video-> data[frame-> channel%3][frame-> frame][y*video-> size[0] +
x], video-> precision);
        fprintf(fp, "%02x", data < 0?0: data > 255?255: data);
    }
    fprintf(fp, "\n");
}
FreeFrame(video, frame-> frame);
fclose(fp);
}

void  Spectrum(w, closure, call_data)

Widget      w;
caddr_t     closure, call_data;

```

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```

{
    Frame frame=(Frame)closure;
    Display      *dpy=XtDisplay(global->toplevel);
    XColor       xcolor[2], falsecolor;
    int          i;
    Colormap     cmap;

    cmap=ChannelCmap(frame->channel,frame->video->type,frame->video->gamma);

    Dprintf("Spectrum\n");
    falsecolor.flags=DoRed|DoGreen|DoBlue;
    XSynchronize(dpy,True);
    for(i=0;i<2+global->levels;i++) {
        if (i>1) XStoreColor(dpy,cmap,&xcolor[i&1]); /* Restore old color */
        if (i<global->levels) {
            xcolor[i&1].pixel=i;
            XQueryColor(dpy,cmap,&xcolor[i&1]);
            falsecolor.pixel=i;
            falsecolor.red=xcolor[i&1].red+32512;
            falsecolor.green=xcolor[i&1].green+32512;
            falsecolor.blue=xcolor[i&1].blue+32512;
            XStoreColor(dpy,cmap,&>falsecolor);
        }
    }
    XSynchronize(dpy,False);
}

```

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source/icon3.c

```

/*
    Create Icons/Menus and set Callbacks
*/

#include    "../include/xwave.h"

/*    Function Name:    FindIcon
 *    Description:    Finds IconRec entry from name in global icon array
 *    Arguments:    icon_name - name of icon bitmap
 *    Returns:    pointer to IconRec with the same name as icon_name
 */

Icon FindIcon(icon_name)

String icon_name;

{
    int    i;
    Icon    icon=NULL;

    for (i=0;i<global->no_icons;i++)
        if (!strcmp(global->icons[i].name,icon_name)) icon=&global->icons[i];
    return(icon);
}

void FillForm(parent,number,items,widgets,callbacks)

int    number;

```

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```

FormItem    items[];
Widget      parent, widgets[];
XtCallbackRec  callbacks[];

{
    Arg    args[10];
    int    i, call_i=0;

    for(i=0;i<number;i++) {
        int    argc=0, *view=(int *)items[i].hook;
        char    text[STRLEN];
        float    top;
        NumInput    num=(NumInput)items[i].hook;
        FloatInput    flt=(FloatInput)items[i].hook;
        Message    msg=(Message)items[i].hook;
        WidgetClass
class[15]={labelWidgetClass,commandWidgetClass,commandWidgetClass,asciiTextWidge
tClass,

menuButtonWidgetClass,menuButtonWidgetClass,viewportWidgetClass,toggleWidgetClass

commandWidgetClass,commandWidgetClass,commandWidgetClass,labelWidgetClass,
scrollbarWidgetClass,labelWidgetClass,formWidgetClass};

        Boolean
call[15]={False,True,True,False,False,False,False,True,True,True,True,False,False,Fals
e,False};

        if (items[i].fromHoriz!=0) {
            XtSetArg(args[argc],XtNfromHoriz,widgets[items[i].fromHoriz-1]);
            argc++;
        }
    }
}

```

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```

if (items[i].fromVert!=0) {
    XtSetArg(args[argc],XtNfromVert,widgets[items[i].fromVert-1]);
    argc++;
}
switch(items[i].type) { /* Initialise contents */
case FW_yn:
    items[i].contents=*(Boolean *)items[i].hook?"confirm":"cancel";
    break;
case FW_up:
    items[i].contents="up";
    break;
case FW_down:
    items[i].contents="down";
    break;
case FW_integer:
    sprintf(text,num->format,*num->value);
    items[i].contents=text;
    break;
case FW_float:
    sprintf(text,flt->format,*flt->value);
    items[i].contents=text;
    break;
}
switch(items[i].type) { /* Set contents */
case FW_label: case FW_command: case FW_button: case FW_integer:
case FW_float:
    XtSetArg(args[argc],XtNlabel,items[i].contents); argc++;
    break;
case FW_down: case FW_up: case FW_yn: case FW_toggle: case
FW_icon: case FW_icon_button: {
    Icon icon=FindIcon(items[i].contents);

```

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```

    if (icon == NULL) {
        XtSetArg(args[argc], XtNlabel, items[i].contents); argc++;
    } else {
        XtSetArg(args[argc], XtNbitmap, icon->pixmap); argc++;
        XtSetArg(args[argc], XtNheight, icon->height+2); argc++;
        XtSetArg(args[argc], XtNwidth, icon->width+2); argc++;
    }
    } break;
}

switch(items[i].type) { /* Individual set-ups */
case FW_text:
    XtSetArg(args[argc], XtNstring, msg->info.ptr); argc++;
    XtSetArg(args[argc], XtNeditType, msg->edit); argc++;
    XtSetArg(args[argc], XtNuseStringInPlace, True); argc++;
    XtSetArg(args[argc], XtNlength, msg->size); argc++;
    break;
case FW_button: case FW_icon_button:
    XtSetArg(args[argc], XtNmenuName, (String)items[i].hook);

argc++;

    break;
case FW_toggle:
    if ((int)items[i].hook == 0) {
        XtSetArg(args[argc], XtNradioData, 1); argc++;
    } else {
        caddr_t radioData;
        Arg radioargs[1];
        Widget radioGroup = widgets[(int)items[i].hook-1];

        XtSetArg(radioargs[0], XtNradioData, &radioData);
        XtGetValues(radioGroup, radioargs, ONE);

        XtSetArg(args[argc], XtNradioData, (caddr_t)((int)radioData+1)); argc++;
    }
}

```

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```

        XtSetArg(args[argc],XtNradioGroup,radioGroup); argc++;
    }
    break;
case FW_scroll:
    top=(float)(*flt->value-flt->min)/(flt->max-flt->min);
    XtSetArg(args[argc],XtNtopOfThumb,&top); argc++;
    XtSetArg(args[argc],XtNjumpProc,&callbacks[call_i]); argc++;
    while(callbacks[call_i].callback!=NULL) call_i++;
    call_i++;
    break;
case FW_view:
    if (view!=NULL) {
        XtSetArg(args[argc],XtNwidth,view[0]); argc++;
        XtSetArg(args[argc],XtNheight,view[1]); argc++;
    }
    break;
}

widgets[i]=XtCreateManagedWidget(items[i].name,class[(int)items[i].type],parent,args,ar
gc);

switch(items[i].type) { /* Post processing */
case FW_toggle:
    if (items[i].hook==NULL) { /* Avoids Xaw bug */
        XtSetArg(args[0],XtNradioGroup,widgets[i]);
        XtSetValues(widgets[i],args,ONE);
    }
    break;
case FW_text: {
    XFontStruct *font;
    Arg    text_args[1];

    msg->widget=widgets[i];

```

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```

XawTextDisplayCaret(msg->widget,msg->edit!=XawtextRead);
XtSetArg(text_args[0],XtNfont,&font);
XtGetValues(widgets[i],text_args,ONE);
argc=0;
if (msg->edit==XawtextRead && msg->info.ptr[0]!='\0')
XtSetArg(args[argc],XtNwidth,4+TextWidth(0,msg->info.ptr,font));
    else
XtSetArg(args[argc],XtNwidth,4+msg->cols*(font->max_bounds.width+font->min_bo
unds.width)/2);
    argc++;

XtSetArg(args[argc],XtNheight,1+msg->rows*(font->max_bounds.ascent+font->max_
bounds.descent)); argc++;
    XtSetValues(widgets[i],args,argc);
    } break;
case FW_button:

XtOverrideTranslations(widgets[i],XtParseTranslationTable("<BtnDown>: reset()
NameButton() PopupMenu()"));
    break;
case FW_down:
    if (*num->value==num->min) XtSetSensitive(widgets[i],False);
    num->widgets[0]=widgets[i];
    break;
case FW_up:
    if (*num->value==num->max) XtSetSensitive(widgets[i],False);
    num->widgets[1]=widgets[i];
    break;
case FW_integer:
    num->widgets[2]=widgets[i];
    break;
case FW_scroll:

```


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```

        flt->widgets[1]=widgets[i];
        XawScrollbarSetThumb(widgets[i],top,0.05);
        break;
    case FW_float:
        flt->widgets[0]=widgets[i];
        break;
    }
    if (call[(int)items[i].type]) { /* Add Callbacks */
        if (callbacks[call_i].callback!=NULL)
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
        while(callbacks[call_i].callback!=NULL) call_i++;
        call_i++;
    }
}
}

```

Widget **ShellWidget(name,parent,type,cmap,callbacks)**

String name;

Widget parent;

ShellWidgetType type;

Colormap cmap;

XtCallbackRec callbacks[];

{

Widget shell;

Arg args[3];

Position x, y;

Dimension height=-2;

int argc=0;

WidgetClass

class[] = {transientShellWidgetClass,transientShellWidgetClass,topLevelShellWidgetClass,p

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```
ullRightMenuWidgetClass};
```

```

if (type == SW_below || type == SW_over) {
    XtTranslateCoords(parent, 0, 0, &x, &y);
    if (type == SW_below) {
        XtSetArg(args[0], XtNheight, &height);
        XtGetValues(parent, args, ONE);
    }
    XtSetArg(args[argc], XtNx, x); argc++;
    XtSetArg(args[argc], XtNy, y + height + 2); argc++;
}
if (cmap != NULL) {
    XtSetArg(args[argc], XtNcolormap, cmap); argc++;
}
shell = XtCreatePopupShell(name, class[type], parent, args, argc);
if (callbacks != NULL) XtAddCallbacks(shell, XtNdestroyCallback, callbacks);
return(shell);

```

```
Widget      FormatWidget(name, parent)
```

```
String name;
```

```
Widget      parent;
```

```

{
    return(XtCreateManagedWidget(name, formWidgetClass, parent, NULL, ZERO));
}

```

```
void FillMenu(parent, number, items, widgets, callbacks)
```

```
int number;
```

```
MenuItem items[];
```

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```

Widget      parent, widgets[];
XtCallbackRec  callbacks[];

{
    Arg      args[4];
    int      i, call_i=0;
    Icon      icon=FindIcon("right");

    for(i=0;i<number;i++) {
        int      argc=0;

        XtSetArg(args[argc],XtNlabel,items[i].label); argc++;
        if (items[i].widgetClass == smeBSBprObjectClass) {
            XtSetArg(args[argc],XtNmenuName,items[i].hook); argc++;
            XtSetArg(args[argc],XtNrightMargin,4+icon->width); argc++;
            XtSetArg(args[argc],XtNrightBitmap,icon->pixmap); argc++;
        }

        widgets[i]=XtCreateManagedWidget(items[i].name,items[i].widgetClass,parent,args,argc)
        ;

        if (items[i].widgetClass == smeBSBObjectClass) { /* Add Callbacks */
            XtAddCallbacks(widgets[i],XtNcallback,&callbacks[call_i]);
            while(callbacks[call_i].callback!=NULL) call_i++;
            call_i++;
        }
    }
}

void SimpleMenu(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

```

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```

{
    int    *hook=(int *)closure, no_child, child, argc=0;
    Widget      menu=XtParent(w), button;
    WidgetList  children;
    char    *label;
    Arg    args[3];

    XtSetArg(args[argc],XtNlabel,&label); argc++;
    XtGetValues(w,args,argc); argc=0;
    XtSetArg(args[argc],XtNchildren,&children); argc++;
    XtSetArg(args[argc],XtNnumChildren,&no_child); argc++;
    XtSetArg(args[argc],XtNbutton,&button); argc++;
    XtGetValues(menu,args,argc); argc=0;
    for(child=0;children[child]!=w && child<no_child;) child++;
    if (w!=children[child]) Eprintf("SimpleMenu: menu error\n");
    *hook=child;
    XtSetArg(args[argc],XtNlabel,label); argc++;
    XtSetValues(button,args,argc);
}

```

```

void  NumIncDec(w,closure,call_data)

```

```

Widget      w;
caddr_t     closure, call_data;

```

```

{
    NumInput  data=(NumInput)closure;
    Arg    args[1];
    char    text[STRLEN];

    *data->value += (w==data->widgets[0])?-1:1;
    sprintf(text,data->format,*data->value);

```

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```

    if (data->min == *data->value) XtSetSensitive(data->widgets[0],False);
    else XtSetSensitive(data->widgets[0],True);
    if (data->max == *data->value) XtSetSensitive(data->widgets[1],False);
    else XtSetSensitive(data->widgets[1],True);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[2],args,ONE);
}

```

```

void FloatIncDec(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t     closure, call_data;

```

```

{
    FloatInput data=(FloatInput)closure;
    Arg  args[1];
    char text[STRLEN];
    float percent=*(float *)call_data;

    *data->value=data->min+(double)percent*(data->max-data->min);
    sprintf(text,data->format,*data->value);
    XtSetArg(args[0],XtNlabel,text);
    XtSetValues(data->widgets[0],args,ONE);
}

```

```

/*  Function Name:      ChangeYN
*
*  Description:  Toggle YN widget state
*
*  Arguments:   w - toggling widget
*
*               closure - pointer to boolean state
*
*               call_data - not used
*
*  Returns:     none.
*/

```

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```
void ChangeYN(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Boolean      *bool=(Boolean *)closure;
```

```
    Icon   icon=FindIcon((*bool != True)?"confirm":"cancel");
```

```
    Arg   args[4];
```

```
    int   argc=0;
```

```
    *bool = ! *bool;
```

```
    XtSetArg(args[argc],XtNbitmap,icon->pixmap); argc++;
```

```
    XtSetArg(args[argc],XtNheight,icon->height+2); argc++;
```

```
    XtSetArg(args[argc],XtNwidth,icon->width+2); argc++;
```

```
    XtSetValues(w,args,argc);
```

```
}
```

```
int TextWidth(max,text,font)
```

```
int   max;
```

```
String text;
```

```
XFontStruct *font;
```

```
{
```

```
    int   i=0, j;
```

```
    while(text[i]!='\0') {
```

```
        int   width;
```

```
        for(j=0;text[i+j]!='\0' && text[i+j]!='\n';) j++;
```

```
        width=XTextWidth(font,&text[i],j);
```

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```

/*
 * Image.c - Image widget
 *
 */

#define XtStrlen(s)      ((s) ? strlen(s) : 0)

#include <stdio.h>
#include <ctype.h>
#include <X11/IntrinsicP.h>
#include <X11/StringDefs.h>
#include <X11/Xaw/XawInit.h>
#include "../include/ImageP.h"

#define streq(a,b) (strcmp( (a), (b) ) == 0)

/*****
 *
 * Full class record constant
 *
 *****/

/* Private Data */

static char defaultTranslations[] =
    "<Btn1Down>: notify()\n\
    <Btn1Motion>: notify()\n\
    <Btn1Up>: notify()";

#define offset(field) XtOffset(ImageWidget, field)

static XtResource resources[] = {
    {XtNbitmap, XtCPixmap, XtRBitmap, sizeof(Pixmap),

```

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```

        offset(image.pixmap), XtRImmediate, (caddr_t)None},
        {XtNcallback, XtCCallback, XtRCallback, sizeof(XtPointer),
        offset(image.callbacks), XtRCallback, (XtPointer)NULL},
};

```

```

static void Initialize();
static void Resize();
static void Redisplay();
static Boolean SetValues();
static void ClassInitialize();
static void Destroy();
static XtGeometryResult QueryGeometry();

```

```

static void Notify(), GetBitmapInfo();

```

```

static XtActionsRec      actionsList[]={
    {"notify",    Notify},
};

```

```

ImageClassRec imageClassRec = {
    {
        /* core_class fields */
#define superclass      (&simpleClassRec)
        /* superclass      */      (WidgetClass) superclass,
        /* class_name      */      "Image",
        /* widget_size      */      sizeof(ImageRec),
        /* class_initialize */      ClassInitialize,
        /* class_part_initialize */  NULL,
        /* class_inited      */      FALSE,
        /* initialize       */      Initialize,
        /* initialize_hook   */      NULL,
        /* realize          */      XtInheritRealize,

```


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```

/* actions          */ actionsList,
/* num_actions      */ XtNumber(actionsList),
/* resources        */ resources,
/* num_resources    */ XtNumber(resources),
/* xrm_class        */ NULLQUARK,
/* compress_motion  */ TRUE,
/* compress_exposure */ TRUE,
/* compress_enterleave */ TRUE,
/* visible_interest */ FALSE,
/* destroy          */ Destroy,
/* resize           */ Resize,
/* expose           */ Redisplay,
/* set_values       */ SetValues,
/* set_values_hook   */ NULL,
/* set_values_almost */ XtInheritSetValuesAlmost,
/* get_values_hook   */ NULL,
/* accept_focus      */ NULL,
/* version           */ XtVersion,
/* callback_private  */ NULL,
/* tm_table          */ defaultTranslations,
/* query_geometry    */ QueryGeometry,
/* display_accelerator */ XtInheritDisplayAccelerator,
/* extension         */ NULL
},
/* Simple class fields initialization */
{
    /* change_sensitive */ XtInheritChangeSensitive
}
};

WidgetClass imageWidgetClass = (WidgetClass)&imageClassRec;
/*****
*

```

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* Private Procedures

*

*****/

static void ClassInitialize()

{

 extern void XmuCvtStringToBitmap();

 static XtConvertArgRec screenConvertArg[] = {

 {XtWidgetBaseOffset, (caddr_t) XtOffset(Widget, core.screen),

 sizeof(Screen *)}

 };

 XawInitializeWidgetSet();

 XtAddConverter("String", "Bitmap", XmuCvtStringToBitmap,

 screenConvertArg, XtNumber(screenConvertArg));

} /* ClassInitialize */

/* ARGSUSED */

static void Initialize(request,new)

Widget request, new;

{

 ImageWidget iw = (ImageWidget) new;

 Dprintf("ImageInitialize\n");

 if (iw->image.pixmap == NULL)

 XtErrorMsg("NoBitmap", "asciiSourceCreate", "XawError",

 "Image widget has no bitmap.", NULL, 0);

 GetBitmapInfo(new);

 if (iw->image.map_width <= 0 || iw->image.map_height <= 0)

 XtErrorMsg("NoDimension", "asciiSourceCreate", "XawError",

 "Image widget illegal map dimension.", NULL, 0);

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```

    if (iw->core.width == 0) iw->core.width=iw->image.map_width;
    if (iw->core.height == 0) iw->core.height=iw->image.map_height;

    (*XtClass(new)->core_class.resize) ((Widget)iw);

} /* Initialize */

/*
 * Repaint the widget window
 */

/* ARGSUSED */
static void Redisplay(w, event, region)
    Widget w;
    XEvent *event;
    Region region;
{
    ImageWidget iw = (ImageWidget) w;

    Dprintf("ImageRedisplay\n");
    if (region != NULL &&
        XRectInRegion(region, 0, 0,
            iw->image.map_width, iw->image.map_height)
        == RectangleOut)
        return;

    XCopyArea(
        XtDisplay(w), iw->image.pixmap, XtWindow(w),
        DefaultGC(XtDisplay(w), XDefaultScreen(XtDisplay(w))),
        0, 0, iw->image.map_width, iw->image.map_height, 0, 0);
}

```

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```

static void Resize(w)
    Widget w;
{
    ImageWidget iw = (ImageWidget)w;
    Dprintf("ImageResize\n");
}

/*
 * Set specified arguments into widget
 */

static Boolean SetValues(current, request, new, args, num_args)
    Widget current, request, new;
    ArgList args;
    Cardinal *num_args;
{
    ImageWidget curiw = (ImageWidget) current;
    ImageWidget reqiw = (ImageWidget) request;
    ImageWidget newiw = (ImageWidget) new;
    Boolean redisplay = False;

    /* recalculate the window size if something has changed. */

    if (curiw->image.pixmap != newiw->image.pixmap)
        XFreePixmap(XtDisplay(curiw), curiw->image.pixmap);
    GetBitmapInfo(newiw);
    newiw->core.width = newiw->image.map_width;
    newiw->core.height = newiw->image.map_height;
    redisplay = True;

    return redisplay || XtIsSensitive(current) != XtIsSensitive(new);
}

```

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```

static void Destroy(w)
    Widget w;
{
    ImageWidget iw = (ImageWidget)w;

    Dprintf("ImageDestroy\n");
}

static XtGeometryResult QueryGeometry(w, intended, preferred)
    Widget w;
    XtWidgetGeometry *intended, *preferred;
{
    register ImageWidget iw = (ImageWidget)w;

    preferred->request_mode = CWWidth | CWHeight;
    preferred->width = iw->image.map_width;
    preferred->height = iw->image.map_height;
    if ( ((intended->request_mode & (CWWidth | CWHeight))
        == (CWWidth | CWHeight)) &&
        intended->width == preferred->width &&
        intended->height == preferred->height)
        return XtGeometryYes;
    else if (preferred->width == w->core.width &&
        preferred->height == w->core.height)
        return XtGeometryNo;
    else
        return XtGeometryAlmost;
}

static void GetBitmapInfo(w)

```

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```

Widget      w;

{
    ImageWidget iw=(ImageWidget)w;
    unsigned int  depth, bw;
    Window      root;
    int         x, y;
    unsigned int  width, height;
    char  buf[BUFSIZ];

    if (iw->image.pixmap != None) {
        if
(!XGetGeometry(XtDisplayOfObject(w),iw->image.pixmap,&root,&x,&y,&width,&height,&bw,&depth)) {
            sprintf(buf, "ImageWidget: %s %s \"%s\".", "Could not",
                "get Bitmap geometry information for Image ",
                XtName(w));
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        iw->image.map_width=(Dimension)width;
        iw->image.map_height=(Dimension)height;
    }
}

/*
 *      Action Procedures
 */

static void  Notify(w,event,params,num_params)

Widget      w;
XEvent      *event;

```

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```
String *params;
Cardinal      *num_params;

{
    ImageWidget iw=(ImageWidget)w;
    XButtonEvent *buttonevent=&event->xbutton;
    int    posn[2]={buttonevent->x,buttonevent->y};

    if (iw->image.map_width <= posn[0] || posn[0] < 0 ||
        iw->image.map_height <= posn[1] || posn[1] < 0) Dprintf("No
ImageNotify\n");
    else {
        Dprintf("ImageNotify\n");
        XtCallCallbackList(w,iw->image.callbacks,posn);
    }
}
```

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source/ImpKlicsTestSA.c

```

/*
    Test harness for KlicsFrameSA() in Klics.SA
*/

#include    "xwave.h"
#include    "KlicsSA.h"

void  ImpKlicsTestSA(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    int      sizeY=SA_WIDTH*SA_HEIGHT,
             sizeUV=SA_WIDTH*SA_HEIGHT/4;
    short    *dst[3]={
        (short *)MALLOC(sizeof(short)*sizeY),
        (short *)MALLOC(sizeof(short)*sizeUV),
        (short *)MALLOC(sizeof(short)*sizeUV),
    }, *src[3];
    Video    video=(Video)MALLOC(sizeof(VideoRec));
    int      i, z;
    char      file_name[STRLEN];
    Bits      bfp;
    Boolean    stillvid;

    strcpy(video->name,((XawListReturnStruct *)call_data)->string);

```


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```

sprintf(file_name, "%s%s/%s%s\\0", global->home, KLICS_SA_DIR, video->name, KLICS
_SA_EXT);

bfp=bopen(file_name, "r");
bread(&stillvid, 1, bfp);
bread(&video->size[2], sizeof(int)*8, bfp);
video->data[0]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->data[1]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->data[2]=(short **)MALLOC(sizeof(short *)*video->size[2]);
video->disk=False;
video->type=YUV;
video->size[0]=SA_WIDTH;
video->size[1]=SA_HEIGHT;
video->UVsample[0]=1;
video->UVsample[1]=1;
video->trans.type=TRANS_None;
for(z=0;z<video->size[2];z++) {
    NewFrame(video,z);
    src[0]=video->data[0][z];
    src[1]=video->data[1][z];
    src[2]=video->data[2][z];
    KlicsFrameSA(z==0 || stillvid?STILL:SEND,src,dst,bfp);
    SaveFrame(video,z);
    FreeFrame(video,z);
}
bclose(bfp);
video->next=global->videos;
global->videos=video;
XtFree(dst[0]);
XtFree(dst[1]);
XtFree(dst[2]);
}

```

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source/ImportKlics.c

```
/*
 *   Importing raw Klics binary files
 */

#include    "xwave.h"
#include    "Klics.h"

extern Bits  bopen();
extern void  bclose(), bread(), bwrite(), bflush();

extern void  SkipFrame();
extern int   HuffRead();
extern Boolean  BlockZero();
extern void  ZeroCoeffs();
extern int   ReadInt();
extern int   Decide();
extern double  DecideDouble();

Boolean  BoolToken(bfp)

Bits  bfp;

{
    Boolean  token;

    bread(&token, 1, bfp);
    return(token);
}
```

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```
void HuffBlock(block,bfp)
```

```
Block block;
```

```
Bits bfp;
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
block[X][Y]=HuffRead(bfp);
```

```
}
```

```
void PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl)
```

```
Block old, addr;
```

```
int x, y, z, oct, sub, channel;
```

```
CompCtrl ctrl;
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->dst,channel,0));
```

```
old[X][Y]=ctrl->dst->data[channel][z][addr[X][Y]];
}
```

```
}
```

```
void DeltaBlock(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

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```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

new[X][Y]=old[X][Y]+delta[X][Y]*step+(delta[X][Y]!=0?negif(delta[X][Y]<0,(step-1)
>>1):0);
}

```

```

void  UpdateBlock(new,addr,z,channel,ctrl)

```

```

int    z, channel;
Block new, addr;
CompCtrl  ctrl;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        ctrl->dst->data[channel][z][addr[X][Y]]=(short)new[X][Y];
}

```

```

void  ReadKlicsHeader(ctrl)

```

```

CompCtrl  ctrl;

```

```

{
    KlicsHeaderRec  head;
    int    i;
    Video dst=ctrl->dst;

    fread(&head,sizeof(KlicsHeaderRec),1,ctrl->bfp->fp);
}

```

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```

ctrl->stillvid=head.stillvid;
ctrl->auto_q=head.auto_q;
ctrl->buf_switch=head.buf_switch;
ctrl->quant_const=head.quant_const;
ctrl->thresh_const=head.thresh_const;
ctrl->cmp_const=head.cmp_const;
ctrl->fps=head.fps;
for(i=0;i<5;i++) ctrl->base_factors[i]=head.base_factors[i];
ctrl->diag_factor=head.diag_factor;
ctrl->chrome_factor=head.chrome_factor;
ctrl->decide=head.decide;
strcpy(dst->name,ctrl->bin_name);
dst->type=head.type;
dst->disk=head.disk;
dst->gamma=head.gamma;
dst->rate=head.rate;
dst->start=head.start;
for(i=0;i<3;i++) dst->size[i]=head.size[i];
for(i=0;i<2;i++) dst->UVsample[i]=head.UVsample[i];
dst->trans=head.trans;
dst->precision=head.precision;
for(i=0;i<(dst->type==MONO?1:3);i++)
    dst->data[i]=(short **)MALLOC(dst->size[2]*sizeof(short *));
}

```

```
void WriteKlicsHeader(ctrl)
```

```
CompCtrl ctrl;
```

```
{
```

```
    KlicsHeaderRec head;
```

```
    int i;
```

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```

    head.stillvid=ctrl->stillvid;
    head.auto_q=ctrl->auto_q;
    head.buf_switch=ctrl->buf_switch;
    head.quant_const=ctrl->quant_const;
    head.thresh_const=ctrl->thresh_const;
    head.cmp_const=ctrl->cmp_const;
    head.fps=ctrl->fps;
    for(i=0;i<5;i++) head.base_factors[i]=ctrl->base_factors[i];
    head.diag_factor=ctrl->diag_factor;
    head.chrome_factor=ctrl->chrome_factor;
    head.decide=ctrl->decide;
    head.type=ctrl->dst->type;
    head.disk=ctrl->dst->disk;
    head.gamma=ctrl->dst->gamma;
    head.rate=ctrl->dst->rate;
    head.start=ctrl->dst->start;
    for(i=0;i<3;i++) head.size[i]=ctrl->dst->size[i];
    for(i=0;i<2;i++) head.UVsample[i]=ctrl->dst->UVsample[i];
    head.trans=ctrl->dst->trans;
    head.precision=ctrl->dst->precision;
    fwrite(&head,sizeof(KlicsHeaderRec),1,ctrl->bfp->fp);
}

```

```
void KlicsTree(mode,x,y,z,oct,sub,channel,ctrl)
```

```
int mode, x, y, z, oct, sub, channel;
```

```
CompCtrl ctrl;
```

```
{
```

```
Block addr, old, new, delta, zero_block={{0,0},{0,0}};
```

```
double norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
```

```
int step;
```

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```

PrevBlock(old,addr,x,y,z,oct,sub,channel,ctrl);
if (mode!=VOID) {
    CalcNormals(ctrl,oct,sub,channel,norms);
    step=norms[0] < 1.0?1:(int)norms[0];
    if (mode==STILL || BlockZero(old)) {
        if (BoolToken(ctrl->bfp)) { /* NON_ZERO_STILL */
            Dprintf("NON_ZERO_STILL\n");
            HuffBlock(delta,ctrl->bfp);
            DeltaBlock(new,old,delta,step);
            UpdateBlock(new,addr,z,channel,ctrl);
        } else {
            Dprintf("ZERO_STILL\n");
            mode=STOP; /* ZERO_STILL */
        }
    } else {
        if (!BoolToken(ctrl->bfp)) { /* BLOCK_SAME */
            Dprintf("BLOCK_SAME\n");
            mode=STOP;
        } else {
            if (!BoolToken(ctrl->bfp)) { /* ZERO_VID */
                Dprintf("ZERO_VID\n");
                ZeroCoeffs(ctrl->dst->data[channel][z],addr);
                mode=VOID;
            } else { /*
BLOCK_CHANGE */
                Dprintf("BLOCK_CHANGE\n");
                HuffBlock(delta,ctrl->bfp);
                DeltaBlock(new,old,delta,step);
                UpdateBlock(new,addr,z,channel,ctrl);
            }
        }
    }
}

```

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```

    } else {
        if (BlockZero(old)) mode=STOP;
        else {
            ZeroCoeffs(ctrl->dst->data[channel][z],addr);
            mode=VOID;
        }
    }

    if (oct>0 && mode!=STOP) {
        Boolean    decend=mode==VOID?True:BoolToken(ctrl->bfp);
        int    X, Y;

        Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,mode);
        if (decend) {
            if (mode!=VOID) Dprintf("OCT_NON_ZERO\n");
            for(Y=0;Y<2;Y++) for(X=0;X<2;X++)
                KlicsTree(mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl);
        } else if (mode!=VOID) Dprintf("OCT_ZERO\n");
    }
}

void KlicsLPF(mode,z,ctrl)

CompCtrl    ctrl;
int    mode, z;

{
    Block addr, old, new, delta;
    int    channel, channels=ctrl->dst->type==MONO?1:3, x, y,
        octs_lum=ctrl->dst->trans.wavelet.space[0],

    size[2]={Size(ctrl->dst,0,0)>>octs_lum+1,Size(ctrl->dst,0,1)>>octs_lum+1};

```


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```

for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
    Boolean    lpf_loc=True;

    if (mode!=STILL) {
        lpf_loc=BoolToken(ctrl->bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
    }
    if (lpf_loc) for(channel=0;channel < channels;channel++) {
        int
octs=ctrl->dst->trans.wavelet.space[ctrl->dst->type==YUV && channel!=0?1:0],
        X, Y, step, value, bits=0;

        double
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};

        PrevBlock(old,addr,x,y,z,octs-1,0,channel,ctrl);
        CalcNormals(ctrl,octs-1,0,channel,norms);
        step=norms[0] < 1.0?1:(int)norms[0];
        if (mode==STILL) {
            for(bits=0,
value=((1 < 8+ctrl->dst->precision)-1)/step;value!=0;bits++)
                value=value > > 1;
            for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
                delta[X][Y]=ReadInt(bits,ctrl->bfp);
            DeltaBlock(new,old,delta,step);
            UpdateBlock(new,addr,z,channel,ctrl);
        } else {
            if (BoolToken(ctrl->bfp)) { /*
LPF_ZERO/LPF_NON_ZERO */

                Dprintf("LPF_NON_ZERO\n");
                HuffBlock(delta,ctrl->bfp);

```

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```

        DeltaBlock(new,old,delta,step);
        UpdateBlock(new,addr,z,channel,ctrl);
    } else Dprintf("LPF_ZERO\n");
    }
}

void KlicsFrame(ctrl,z)

CompCtrl  ctrl;
int       z;

{
    Video dst=ctrl->dst;
    int   sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND,
        octs_lum=dst->trans.wavelet.space[0],

size[2]={Size(dst,0,0)>>1+octs_lum,Size(dst,0,1)>>1+octs_lum};

    NewFrame(dst,z);
    CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
    if (z!=0 && ctrl->auto_q) {

ctrl->quant_const+=(double)(HISTO/2+ReadInt(HISTO_BITS,ctrl->bfp))*HISTO_DE
LTA*2.0/HISTO-HISTO_DELTA;
        ctrl->quant_const=ctrl->quant_const<0.0?0.0:ctrl->quant_const;
        Dprintf("New quant %f\n",ctrl->quant_const);
    }
    KlicsLPF(mode,z,ctrl);
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        if (BoolToken(ctrl->bfp)) {

```

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```

Dprintf("LOCAL_NON_ZERO\n");
for(channel=0;channel < (dst->type == MONO?1:3);channel++) {
    int    octs=dst->trans.wavelet.space[dst->type == YUV
&& channel!=0?1:0];

    if (BoolToken(ctrl->bfp)) {
        Dprintf("CHANNEL_NON_ZERO\n");
        for(sub=1;sub < 4;sub++)
            KlicsTree(mode,x,y,z,octs-1,sub,channel,ctrl);
    } else Dprintf("CHANNEL_ZERO\n");
}
} else Dprintf("LOCAL_ZERO\n");
}
}

```

```

void ImportKlics(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t     closure, call_data;

```

```

{

```

```

    char    file_name[STRLEN];

```

```

    CompCtrlRec ctrl;

```

```

    int     i, z;

```

```

    ctrl.dst=(Video)MALLOC(sizeof(VideoRec));

```

```

    strcpy(ctrl.bin_name,((XawListReturnStruct *)call_data)->string);

```

```

    sprintf(file_name,"%s%s/%s%s\0",global->home,KLICS_DIR,ctrl.bin_name,KLICS_EX
T);

```

```

    ctrl.bfp=bopen(file_name,"r");

```

```

    ReadKlicsHeader(&ctrl);

```

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```
if (ctrl.dst->disk) SaveHeader(ctrl.dst);
for(z=0;z<ctrl.dst->size[2];z++) {
    if (z==0 || !ctrl.buf_switch) KlicsFrame(&ctrl,z);
    else {
        if (BoolToken(ctrl.bfp)) KlicsFrame(&ctrl,z);
        else SkipFrame(ctrl.dst,z);
    }
    if (z>0) {
        SaveFrame(ctrl.dst,z-1);
        FreeFrame(ctrl.dst,z-1);
    }
}
SaveFrame(ctrl.dst,ctrl.dst->size[2]-1);
FreeFrame(ctrl.dst,ctrl.dst->size[2]-1);
bclose(ctrl.bfp);
ctrl.dst->next=global->videos;
global->videos=ctrl.dst;
}
```

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```
source/ImportKlicsSA.c
```

```
*****/
```

```
/*
```

```
 *   Importing raw Klics binary files
```

```
 *
```

```
 *   Stand Alone version
```

```
*/
```

```
#include "KlicsSA.h"
```

```
extern void Convolve();
```

```
/* useful X definitions */
```

```
typedef char Boolean;
```

```
#define True 1
```

```
#define False 0
```

```
#define String char*
```

```
extern int HuffReadSA();
```

```
extern Boolean BlockZeroSA();
```

```
extern void ZeroCoeffsSA();
```

```
extern int ReadIntSA();
```

```
extern int DecideSA();
```

```
extern double DecideDoubleSA();
```

```
Boolean BoolTokenSA(bfp)
```

```
Bits bfp;
```

```
{
```

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```

    Boolean    token;

    bread(&token,1,bfp);
    return(token);
}

void HuffBlockSA(block,bfp)

Block block;
Bits bfp;

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        block[X][Y]=HuffReadSA(bfp);
}

void PrevBlockSA(old,addr,x,y,oct,sub,channel,dst)

Block old, addr;
int x, y, oct, sub, channel;
short *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        old[X][Y]=dst[channel][addr[X][Y]];
    }
}

```

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```
void DeltaBlockSA(new,old,delta,step)
```

```
Block new, old, delta;
```

```
int step;
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
new[X][Y]=old[X][Y]+delta[X][Y]*step+(delta[X][Y]!=0?negif(delta[X][Y]<0,(step-1)
>>1):0);
```

```
}
```

```
void UpdateBlockSA(new,addr,channel,dst)
```

```
int channel;
```

```
Block new, addr;
```

```
short *dst[3];
```

```
{
```

```
int X, Y;
```

```
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
```

```
dst[channel][addr[X][Y]]=(short)new[X][Y];
```

```
}
```

```
void KlicsTreeSA(mode,x,y,oct,sub,channel,dst,bfp,quant_const)
```

```
int mode, x, y, oct, sub, channel;
```

```
short *dst[3];
```

```
Bits bfp;
```

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```
double    quant_const;
```

```
{
```

```
Block addr, old, new, delta, zero_block={{0,0},{0,0}};
```

```
double    norms[3]={quant_const,thresh_const,cmp_const};
```

```
int    step;
```

```
PrevBlockSA(old,addr,x,y,oct,sub,channel,dst);
```

```
if (mode!=VOID) {
```

```
    CalcNormalsSA(oct,sub,channel,norms,quant_const);
```

```
    step=norms[0] < 1.0?1:(int)norms[0];
```

```
    if (mode==STILL || BlockZero(old)) {
```

```
        if (BoolTokenSA(bfp)) { /* NON_ZERO_STILL */
```

```
            Dprintf("NON_ZERO_STILL\n");
```

```
            HuffBlockSA(delta,bfp);
```

```
            DeltaBlockSA(new,old,delta,step);
```

```
            UpdateBlockSA(new,addr,channel,dst);
```

```
        } else {
```

```
            Dprintf("ZERO_STILL\n");
```

```
            mode=STOP; /* ZERO_STILL */
```

```
        }
```

```
    } else {
```

```
        if (!BoolTokenSA(bfp)) { /* BLOCK_SAME */
```

```
            Dprintf("BLOCK_SAME\n");
```

```
            mode=STOP;
```

```
        } else {
```

```
            if (!BoolTokenSA(bfp)) { /* ZERO_VID */
```

```
                Dprintf("ZERO_VID\n");
```

```
                ZeroCoeffsSA(dst[channel],addr);
```

```
                mode=VOID;
```

```
            } else {
```

```
/*
```

```
BLOCK_CHANGE */
```


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```

        Dprintf("BLOCK_CHANGE\n");
        HuffBlockSA(delta,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    }
}

} else {
    if (BlockZeroSA(old)) mode=STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        mode=VOID;
    }
}

if (oct>0 && mode!=STOP) {
    Boolean    decend=mode==VOID?True:BoolTokenSA(bfp);
    int    X, Y;

    Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,mode);
    if (decend) {
        if (mode!=VOID) Dprintf("OCT_NON_ZERO\n");
        for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

KlicsTreeSA(mode,x*2+X,y*2+Y,oct-1,sub,channel,dst,bfp,quant_const);
    } else if (mode!=VOID) Dprintf("OCT_ZERO\n");
}

}

void  KlicsLPF_SA(mode,dst,bfp,quant_const)

int    mode;

```

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```

short  *dst[3];
Bits   bfp;
double  quant_const;

{
    Block addr, old, new, delta;
    int   channel, channels=3, x, y,
          octs_lum=3,

size[2]={SA_WIDTH>>octs_lum+1,SA_HEIGHT>>octs_lum+1};

    for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
        Boolean   lpf_loc=True;

        if (mode!=STILL) {
            lpf_loc=BoolTokenSA(bfp); /*
LPF_LOC_ZERO/LPF_LOC_NON_ZERO */

Dprintf("%s\n",lpf_loc?"LPF_LOC_NON_ZERO":"LPF_LOC_ZERO");
        }
        if (lpf_loc) for(channel=0;channel < channels;channel++) {
            int     octs=channel!=0?2:3,
                    X, Y, step, value, bits=0;
            double   norms[3]={quant_const,thresh_const,cmp_const};

            PrevBlockSA(old,addr,x,y,octs-1,0,channel,dst);
            CalcNormalsSA(octs-1,0,channel,norms,quant_const);
            step=norms[0] < 1.0?1:(int)norms[0];
            if (mode==STILL) {
                for(bits=0,
value=((1 < < 8+SA_PRECISION)-1)/step;value!=0;bits++)
                    value=value>>1;

```

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```

        for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
            delta[X][Y]=ReadIntSA(bits,bfp);
        DeltaBlockSA(new,old,delta,step);
        UpdateBlockSA(new,addr,channel,dst);
    } else {
        if (BoolTokenSA(bfp)) { /* LPF_ZERO/LPF_NON_ZERO
*/
            Dprintf("LPF_NON_ZERO\n");
            HuffBlockSA(delta,bfp);
            DeltaBlockSA(new,old,delta,step);
            UpdateBlockSA(new,addr,channel,dst);
        } else Dprintf("LPF_ZERO\n");
    }
}
}
}

```

```

void KlicsFrameSA(mode,src,dst,bfp)

```

```

    int    mode;

```

```

    short  *src[3], *dst[3];

```

```

    Bits   bfp;

```

```

{

```

```

    int    sub, channel, x, y, i,

```

```

        octs_lum=3,

```

```

size[2]={SA_WIDTH>>1+octs_lum,SA_HEIGHT>>1+octs_lum};

```

```

    double    quant_const;

```

```

    bread((char *)&quant_const,sizeof(double)*8,bfp);

```

```

    KlicsLPF_SA(mode,dst,bfp,quant_const);

```

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```

for(y=0;y < size[1];y++) for(x=0;x < size[0];x++) {
    if (BoolTokenSA(bfp)) {
        Dprintf("LOCAL_NON_ZERO\n");
        for(channel=0;channel < 3;channel++) {
            int    octs=channel!=0?2:3;

            if (BoolTokenSA(bfp)) {
                Dprintf("CHANNEL_NON_ZERO\n");
                for(sub=1;sub < 4;sub++)

KlicsTreeSA(mode,x,y,octs-1,sub,channel,dst,bfp,quant_const);
            } else Dprintf("CHANNEL_ZERO\n");
        }
    } else Dprintf("LOCAL_ZERO\n");
}

for(channel=0;channel < 3;channel++) {
    int
frame_size[2]={SA_WIDTH >> (channel==0?0:1),SA_HEIGHT >> (channel==0?0:1
)},

    frame_area=frame_size[0]*frame_size[1];

    for(i=0;i < frame_area;i++) src[channel][i]=dst[channel][i];
    Convolve(src[channel],False,frame_size,channel==0?3:2,0);
    for(i=0;i < frame_area;i++)
src[channel][i]=src[channel][i] >> SA_PRECISION;
}
}

```

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source/InitFrame.c

/*

Initialise frame structure for Frame command widget

*/

#include "../include/xwave.h"

#define FRAME_ICONS 14

#define TRANS_MENU 1

#define COMP_MENU 2

extern void CopyVideo();

extern void Compare();

extern void NA();

extern void FrameDestroy();

extern void Examine();

extern void FramePointYN();

extern void FrameInfo();

extern void FrameMerge();

extern void Movie();

extern void PostScript();

extern void Select();

extern void Spectrum();

extern void NewPoint();

extern void Transform();

extern void Compress();

extern String *VideoCurrentList();

extern void KlicsSA();

void InitFrame (w,closure,call_data)

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```

Widget      w;
caddr_t     closure, call_data;

{
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    Video video=FindVideo(name->string,global->videos);
    Frame frame=(Frame)MALLOC(sizeof(FrameRec));
    Widget     shell[2], form, widgets[FRAME_ICONS],
trans_widgets[TRANS_MENU], comp_widgets[COMP_MENU];
    Arg      args[7];
    Pixmap    pixmap;
    int      view[2]={15+video->size[0],15+video->size[1]};
    FormItem  items[]={
        {"frm_cancel",      "frame_close",          0,0,FW_icon,NULL},
        {"frm_copy", "copy",          1,0,FW_icon,NULL},
        {"frm_exam",      "examine",          2,0,FW_icon,NULL},
        {"frm_point_yn","point_y",          3,0,FW_icon,NULL},
        {"frm_transform","transform",
4,0,FW_icon_button,"frm_trans_menu"},
        {"frm_info_yn",      "info",
5,0,FW_icon,NULL},
        {"frm_merge",      "merge",          6,0,FW_toggle,NULL},
        {"frm_compress","code",
7,0,FW_icon_button,"frm_comp_menu"},
        {"frm_movie",      "movie",          8,0,FW_icon,NULL},
        {"frm_postscript","postscript",      9,0,FW_icon,NULL},
        {"frm_compare",      "compare",      10,0,FW_icon,NULL},
        {"frm_view", NULL,
0,1,FW_view,(String)view},
        {"frm_label", video->name,          0,12,FW_label,NULL},
        {"frm_colors",      "colors",          13,12,FW_icon,NULL},
    };
};

```

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```

Selection    sel = (Selection)MALLOC(sizeof(SelectItem));
MenuItem     trans_menu[TRANS_MENU]={
    {"trans_Wavelet",smeBSBObjectClass,"Wavelet",NULL},
};
MenuItem     comp_menu[COMP_MENU]={
    {"comp_KLICS",smeBSBObjectClass,"KLICS",NULL},
    {"comp_KLICS_SA",smeBSBObjectClass,"KLICS SA",NULL},
};
XtCallbackRec frame_call[]={
    {FrameDestroy,(caddr_t)frame}, {Free,(caddr_t)sel}, {NULL,NULL},
    {CopyVideo,(caddr_t)video}, {NULL,NULL},
    {Examine,(caddr_t)frame}, {NULL,NULL},
    {FramePointYN,(caddr_t)frame}, {NULL,NULL},
    {FrameInfo,(caddr_t)frame}, {NULL,NULL},
    {FrameMerge,(caddr_t)frame}, {NULL,NULL},
    {Movie,(caddr_t)frame}, {NULL,NULL},
    {PostScript,(caddr_t)frame}, {NULL,NULL},
    {Select,(caddr_t)sel}, {NULL,NULL},
    {Spectrum,(caddr_t)frame}, {NULL,NULL},
}, image_call[]={
    {NewPoint,(caddr_t)frame}, {NULL,NULL},
}, trans_call[]={
    {Transform,(caddr_t)video}, {NULL,NULL},
}, comp_call[]={
    {Compress,(caddr_t)video}, {NULL,NULL},
    {KlicsSA,(caddr_t)video}, {NULL,NULL},
};
Colormap      cmap=ChannelCmap(frame->channel=(video->type==MONO
|| video->trans.type!=TRANS_None)?0:3,video->type,video->gamma);

Dprintf("InitFrame\n");

```

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```
sel->name="video_Compare";
sel->button="frm_compare";
sel->list_proc=VideoCurrentList;
sel->action_name="Compare videos";
sel->action_proc=Compare;
sel->action_closure=(caddr_t)video;
frame->video=video;
frame->shell=ShellWidget("frm_shell",global->toplevel,SW_top,cmap,NULL);
form=FormatWidget("frm_form",frame->shell);
frame->image_widget=NULL;

frame->msg=NULL;

frame->zoom=0;
frame->frame=0;

frame->point_switch=False;
frame->point_merge=False;

frame->point=(Point)MALLOC(sizeof(PointRec));
frame->point->location[0]=0;
frame->point->location[1]=0;
frame->point->usage=1;
frame->point->next=global->points;
global->points=frame->point;

frame->palette=0;

frame->next=global->frames;
global->frames=frame;

GetFrame(video,frame->frame);
```


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```

pixmap=UpdateImage(frame);

FillForm(form,FRAME_ICONS,items,widgets,frame_call);
shell[0]=ShellWidget("frm_trans_menu",widgets[4],SW_menu,NULL,NULL);
FillMenu(shell[0],TRANS_MENU,trans_menu,trans_widgets,trans_call);
shell[1]=ShellWidget("frm_comp_menu",widgets[7],SW_menu,NULL,NULL);
FillMenu(shell[1],COMP_MENU,comp_menu,comp_widgets,comp_call);

frame->point_merge_widget=widgets[6];

XtSetArg(args[0],XtNbitmap,pixmap);
XtSetArg(args[1],XtNwidth,video->size[0]);
XtSetArg(args[2],XtNheight,video->size[1]);
XtSetArg(args[3],XtNcallback,image_call);

frame->image_widget=XtCreateManagedWidget("frm_image",imageWidgetClass,widget
s[11],args,FOUR);
XtSetSensitive(frame->image_widget,False);
XtSetSensitive(widgets[13],PseudoColor==global->visinfo->class);
XtPopup(frame->shell,XtGrabNone);
}

```

Video FindVideo(name,video)

String name;

Video video;

```

{
    if (video==NULL) return(NULL);
    else if (!strcmp(name,video->name)) return(video);
        else return(FindVideo(name,video->next));
}

```

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source/InitMain.c

```
/*  
    Initialise menu structure for Main command widget  
*/  
  
#include    "../include/xwave.h"  
  
/* Save externs */  
  
extern void  VideoSave();  
extern void  VideoXimSave();  
extern void  VideoDTSave();  
extern void  VideoMacSave();  
extern void  VideoHexSave();  
  
/* List externs */  
  
extern String *VideoList();  
extern String *VideoDropList();  
extern String *VideoCurrentList();  
extern String *KlicsList();  
extern String *KlicsListSA();  
  
/* Import externs */  
  
extern void  ImportKlics();  
extern void  ImpKlicsTestSA();  
  
/* Main externs */
```

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```

extern void  Select();
extern void  VideoClean();
extern void  Quit();
extern void  VideoLoad();
extern void  InitFrame();
extern void  VideoDrop();
extern void  PlotGraph();

```

```

/*      Function Name:      InitMain
*      Description:  Create main menu button & sub-menus
*      Arguments:    none
*      Returns:      none
*/

```

```

#define      MAIN_MENU      7
#define      SAVE_MENU      5
#define      IMPT_MENU      2

```

```

InitMain()

```

```

{
    Widget      form=FormatWidget("xwave_form",global->toplevel), widgets[1],
               main_shell, main_widgets[MAIN_MENU],
               save_shell, save_widgets[SAVE_MENU],
               impt_shell, impt_widgets[IMPT_MENU];

    FormItem    items[]={
        {"xwaveLogo","main",0,0,FW_icon_button,"xwave_main_sh"},
    };

    MenuItem    main_menu[]={
        {"main_Open",smeBSBObjectClass,"Open a video",NULL},
        {"main_Attach",smeBSBObjectClass,"Attach a frame",NULL},
        {"main_Save",smeBSBprObjectClass,"Save a video","xwave_save_sh"},
    };
}

```

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```

        {"main_Drop",smeBSBObjectClass,"Drop a video",NULL},
        {"main_Clean",smeBSBObjectClass,"Clean out videos",NULL},
        {"main_Import",smeBSBprObjectClass,"Import a
video","xwave_impt_sh"},
        {"main_Quit",smeBSBObjectClass,"Quit",NULL},
    }, save_menu[]={
        {"save_menu_vid",smeBSBObjectClass,"Save xwave video",NULL},
        {"save_menu_xim",smeBSBObjectClass,"Save xim video",NULL},
        {"save_menu_dt",smeBSBObjectClass,"Save DT image",NULL},
        {"save_menu_mac",smeBSBObjectClass,"Save mac video",NULL},
        {"save_menu_hex",smeBSBObjectClass,"Save hex dump",NULL},
    }, impt_menu[]={
        {"impt_menu_klics",smeBSBObjectClass,"KLICS",NULL},
        {"impt_menu_klicsSA",smeBSBObjectClass,"KLICS SA",NULL},
    };
    static SelectItem selection[]={
        {"video_Open","xwaveLogo",VideoList,"Open a
video",VideoLoad,NULL},
        {"frame_Attach","xwaveLogo",VideoCurrentList,"Attach a
frame",InitFrame,NULL},
        {"video_Drop","xwaveLogo",VideoDropList,"Drop a
video",VideoDrop,NULL},
    }, save_sel[]={
        {"save_vid","xwaveLogo",VideoCurrentList,"Save xwave
video",VideoSave,NULL},
        {"save_xim","xwaveLogo",VideoCurrentList,"Save xim
video",VideoXimSave,NULL},
        {"save_dt","xwaveLogo",VideoCurrentList,"Save DT
image",VideoDTSave,NULL},
        {"save_mac","xwaveLogo",VideoCurrentList,"Save mac
video",VideoMacSave,NULL},
        {"save_hex","xwaveLogo",VideoCurrentList,"Save hex

```

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```

'dump',VideoHexSave,NULL},
    }, impt_sel[]={
        {"impt_klics","xwaveLogo",KlicsList,"Import
KLICS",ImportKlics,NULL},
        {"impt_klicsSA","xwaveLogo",KlicsListSA,"Import KLICS
SA",ImpKlicsTestSA,NULL},
    };
XtCallbackRec      main_call[]={
    {Select,(caddr_t)&selection[0]}, {NULL,NULL},
    {Select,(caddr_t)&selection[1]}, {NULL,NULL},
    {Select,(caddr_t)&selection[2]}, {NULL,NULL},
    {VideoClean,(caddr_t)NULL}, {NULL,NULL},
    {Quit,(caddr_t)NULL}, {NULL,NULL},
}, save_call[]={
    {Select,(caddr_t)&save_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[1]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[2]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[3]}, {NULL,NULL},
    {Select,(caddr_t)&save_sel[4]}, {NULL,NULL},
}, impt_call[]={
    {Select,(caddr_t)&impt_sel[0]}, {NULL,NULL},
    {Select,(caddr_t)&impt_sel[1]}, {NULL,NULL},
};
Dprintf("InitMain\n");
FillForm(form,ONE,items,widgets,NULL);
main_shell=ShellWidget("xwave_main_sh",widgets[0],SW_menu,NULL,NULL);
save_shell=ShellWidget("xwave_save_sh",main_shell,SW_menu,NULL,NULL);
impt_shell=ShellWidget("xwave_impt_sh",main_shell,SW_menu,NULL,NULL);
FillMenu(main_shell,MAIN_MENU,main_menu,main_widgets,main_call);
FillMenu(save_shell,SAVE_MENU,save_menu,save_widgets,save_call);
FillMenu(impt_shell,IMPT_MENU,impt_menu,impt_widgets,impt_call);
}

```

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source/Klics5.c

```

/*
    Full still/video Knowles-Lewis Image Compression System utilising HVS
    properties
    and delta-tree coding
*/

#include "xwave.h"
#include "Klics.h"
#include <math.h>

extern Bits bopen();
extern void bclose(), bread(), bwrite(), bflush();

extern WriteKlicsHeader();

/* token modes (empty) */
#define EMPTY 0
#define CHANNEL_EMPTY 1
#define OCTAVE_EMPTY 2
#define LPF_EMPTY 3
#define FULL 4

typedef struct _HistRec {
    int bits, octbits[3][5], lpf, activity, target, token[TOKENS], coeff[129];
    double q_const;
} HistRec, *Hist; /* history record */

/* Function Name: Access
 * Description: Find index address from co-ordinates

```

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```

*   Arguments:  x, y - (x,y) co-ordinates
*               oct, sub, channel - octave, sub-band and channel co-ordinates
*               width - image data width
*   Returns: index into vid->data[channel][index]
*/

```

```
int   Access(x,y,oct,sub,width)
```

```
int   x, y, oct, sub, width;
```

```

{
    return((((x < 1)+(sub > 1)+width*((y < 1)+(1&sub)))) < oct);
}

```

```

/*   Function Name:    LastFrame
*   Description:    Find last frame encoded
*   Arguments:    z - index of current frame
*               hist - history records
*   Returns:    index of previous frame
*/

```

```
int   LastFrame(z,hist)
```

```
int   z;
```

```
Hist hist;
```

```

{
    int   i=z-1;

    while(hist[i].bits==0 && i>0) i--;
    return(i<0?0:i);
}

```

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```

/*  Function Name:    Decide
 *   Description:    Calculate value representing the difference between new and old
blocks
 *   Arguments:    new, old - blocks to compare
 *
 *                   mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
 *   Returns:      difference value
 */

```

```

int  Decide(new,old,mode)

```

```

Block new, old;

```

```

int  mode;

```

```

{

```

```

    int  X, Y, sigma=0;

```

```

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {

```

```

        int  n_o=new[X][Y]-old[X][Y];

```

```

        switch(mode) {

```

```

        case MAXIMUM:

```

```

            sigma=sigma>abs(n_o)?sigma:abs(n_o);

```

```

            break;

```

```

        case SIGABS:

```

```

            sigma+=abs(n_o);

```

```

            break;

```

```

        case SIGSQR:

```

```

            sigma+=n_o*n_o;

```

```

            break;

```

```

        }

```

```

    }

```


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```
    return(sigma);
}

/*  Function Name:    DecideDouble
 *   Description:    Calculates normal w.r.t differencing algorithm
 *   Arguments:    norm - normal value
 *
 *                  mode - differencing algorithm {MAXIMUM | SIGABS |
SIGSQR}
 *   Returns:    new normal value
 */
```

```
double    DecideDouble(norm,mode)
```

```
double    norm;
```

```
int    mode;
```

```
{
    double    ret;

    switch(mode) {
    case MAXIMUM:
        ret = norm;
        break;
    case SIGABS:
        ret = 4.0*norm;
        break;
    case SIGSQR:
        ret = 4.0*norm*norm;
        break;
    }
    return(ret);
}
```

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Boolean Decision(new,old,norm,mode)

Block new, old;

double norm;

int mode;

```
{
    return((double)Decide(new,old,mode) <= DecideDouble(norm,mode));
}
```

/* Function Name: Feedback

* Description: Calculates new target activity from target bits and historical values

* Arguments: hist - history records

* curr - current frame

* taps - size of history window

* Returns: target activity

*/

int Feedback(hist,curr,taps)

int curr;

Hist hist;

int taps;

```
{
    int      prev=curr, i;
    double      ratio=0;

    for(i=0;i < taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
```

```
ratio += (double)hist[prev].activity / ((double)(hist[prev].bits - (prev == 0 ? hist[0].lpf : 0)));
```

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```

    }
    return((int)(ratio*(double)hist[curr].target/(double)i));
}

/*  Function Name:      Filter
 *  Description:  Calculates new q_const filtering historical values
 *  Arguments:   hist - history records
 *               curr - current frame
 *               taps - size of history window
 *               filter - index to filter
 *  Returns:     q_const
 */

```

```

double      Filter(hist,curr,taps,filter)

int      curr;
Hist      hist;
int      taps, filter;

{
    double      mac=hist[curr].q_const, sum=1.0, coeff=1.0;
    int      i, prev=curr;

    for(i=0;i<taps && prev!=0;i++) {
        prev=LastFrame(prev,hist);
        coeff=filter==0?0:coeff/2.0;
        mac+=hist[prev].q_const*coeff;
        sum+=coeff;
    }
    return(mac/sum);
}

```

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```

/*  Function Name:    Huffman
 *  Description:    Calculates the number of bits for the Huffman code representing
level
 *  Arguments:    level - level to be encoded
 *  Returns:      number of bits in codeword
 */

```

```

int  Huffman(level)

```

```

int  level;

```

```

{
    return(level == 0?2:(abs(level) < 3?3:1+abs(level)));
}

```

```

/*  Function Name:    HuffCode
 *  Description:    Generates Huffman code representing level
 *  Arguments:    level - level to be encoded
 *  Returns:      coded bits in char's
 */

```

```

unsigned char *HuffCode(level)

```

```

int  level;

```

```

{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3) | (level < 0?4:0);
    if (abs(level) > 2) {
        int  index=(7+Huffman(level))/8-1;

```

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```

        bytes[index]=bytes[index]|(1 < (Huffman(level)-1)%8);
    }
    return(bytes);
}

```

```

unsigned char *CodeInt(number,bits)

```

```

int    number, bits;

```

```

{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number>>8;
    }
    return(bytes);
}

```

```

int    ReadInt(bits,bfp)

```

```

int    bits;

```

```

Bits    bfp;

```

```

{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);

```

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```

for(byte=0;byte < len;byte++)
    number = number | ((int)bytes[byte] << byte*8);
number = (number << sizeof(int)*8-bits) >> sizeof(int)*8-bits;
return(number);
}

```

```

/*  Function Name:      HuffRead
 *  Description:      Read Huffman encoded number from binary file
 *  Arguments:      bfp - binary file pointer
 *  Returns:      decoded level
 */

```

```

int  HuffRead(bfp)

```

```

Bits  bfp;

```

```

{
    int    value;
    unsigned char    byte;
    Boolean    negative=False;

    bread(&byte,2,bfp);
    value=(int)byte;
    if (byte=='\0') return(0);
    else {
        bread(&byte,1,bfp);
        negative=(byte!='\0');
    }
    if (value < 3) return(negif(negative,value));
    for(byte='\0';byte=='\0';value++) bread(&byte,1,bfp);
    return(negif(negative,value-1));
}

```

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```

/*  Function Name:    Quantize
 *   Description:    RM8 style quantizer
 *   Arguments:    data - unquantised number
 *                  q - quantizing divisor
 *                  level - quantised to level
 *   Returns:      quantized data & level
 */

```

```

int  Quantize(data,q,level)

```

```

int  data, q, *level;

```

```

{
    int  mag_level=abs(data)/q;

    *level=negif(data<0,mag_level);
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
}

```

```

/*  Function Name:    Proposed
 *   Description:    Calculates proposed block values
 *   Arguments:    pro - proposed block
 *                  lev - proposed block quantized levels
 *                  old, new - old and new block values
 *                  decide - decision algorithm
 *                  norms - HVS normals
 *   Returns:      new == 0, proposed values (pro) and levels (lev)
 */

```

```

Boolean  Proposed(pro,lev,old,new,decide,norms)

```

```

Block  pro, lev, old, new;

```

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```

int    decide;
double    norms[3];

{
    Block zero_block={{0,0},{0,0}};
    int    X, Y, step=norms[0]<1.0?1:(int)norms[0];
    Boolean    zero=Decision(new,zero_block,norms[1],decide);

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

    pro[X][Y]=zero?0:old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*    Function Name:    ZeroCoeffs
*    Description:    Zero out video data
*    Arguments:    data - image data
*                  addr - addresses
*    Returns:    zeros data[addr[]]
*/

```

```

void    ZeroCoeffs(data,addr)

```

```

short    *data;
Block    addr;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;
}

```


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```

/*  Function Name:    BlockZero
 *   Description:    Test if all block values are zero
 *   Arguments:    block - block under test
 *   Returns:      block == 0
 */

```

```

Boolean    BlockZero(block)

```

```

Block block;

```

```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        if (block[X][Y]!=0) zero=False;
    return(zero);
}

```

```

/*  Function Name:    SendToken
 *   Description:    Increments token frequency
 *   Arguments:    token - token to be transmitted
 *                  channel, sub, oct - co-ordinates
 *                  ctrl - control record for compresssion
 *                  hist - history record
 *                  empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
 *                  branch - branch of tree (0-3)
 *   Returns:      encodes token
 */

```

```

void    SendToken(token,channel,sub,oct,ctrl,hist,empty,branch)

```

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```

int    token, channel, sub, oct, *empty, branch;
CompCtrl  ctrl;
Hist  hist;

{
    int    full=FULL, i;
    String
token_name[TOKENS]={ "ZERO_STILL", "NON_ZERO_STILL", "BLOCK_SAME", "ZE
RO_VID", "BLOCK_CHANGE",

"LOCAL_ZERO", "LOCAL_NON_ZERO", "CHANNEL_ZERO", "CHANNEL_NON_ZE
RO", "OCT_ZERO", "OCT_NON_ZERO",

"LPF_ZERO", "LPF_NON_ZERO", "LPF_LOC_ZERO", "LPF_LOC_NON_ZERO"};

    switch(*empty) {
    case EMPTY:
        if (token!=ZERO_STILL && token!=BLOCK_SAME) {

SendToken(LOCAL_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i<channel;i++)
SendToken(CHANNEL_ZERO,i,sub,oct,ctrl,hist,&full,branch);
        *empty=CHANNEL_EMPTY;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
        }
        break;
    case CHANNEL_EMPTY:
        if (token!=ZERO_STILL && token!=BLOCK_SAME) {

SendToken(CHANNEL_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=1;i<sub;i++)
SendToken(token==NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME,channel,i,oct,ct

```

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```

    rl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case OCTAVE_EMPTY:
    if (token! = ZERO_STILL && token! = BLOCK_SAME) {

SendToken(OCT_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < branch;i++)
SendToken(token == NON_ZERO_STILL?ZERO_STILL:BLOCK_SAME,channel,sub,oc
t,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token! = LPF_ZERO) {

SendToken(LPF_LOC_NON_ZERO,channel,sub,oct,ctrl,hist,&full,branch);
        for(i=0;i < channel;i++)
SendToken(LPF_ZERO,i,sub,oct,ctrl,hist,&full,branch);
        *empty = FULL;
        SendToken(token,channel,sub,oct,ctrl,hist,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    hist->token[token]++;
    hist->bits += token_bits[token];
    hist->octbits[channel][oct] += token_bits[token];
    if (ctrl->bin_switch)

```

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```
bwrite(&token_codes[token],token_bits[token],ctrl->bfp);
```

```
    break;
```

```
    }
```

```
}
```

```
/*    Function Name:    ReadBlock
 *    Description:    Read block from video
 *    Arguments:    new, old, addr - new and old blocks and addresses
 *                  x, y, z, oct, sub, channel - co-ordinates of block
 *                  ctrl - compression control record
 *    Returns:    block values
 */
```

```
void ReadBlock(new,old,addr,x,y,z,oct,sub,channel,ctrl)
```

```
Block new, old, addr;
```

```
int x, y, z, oct, sub, channel;
```

```
CompCtrl ctrl;
```

```
{
```

```
    int X, Y;
```

```
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
```

```
        addr[X][Y]=Access((x<<1)+X,(y<<1)+Y,oct,sub,Size(ctrl->src,channel,0));
```

```
        new[X][Y]=(int)ctrl->src->data[channel][z][addr[X][Y]];

```

```
        old[X][Y]=(int)ctrl->dst->data[channel][z][addr[X][Y]];

```

```
    }
```

```
}
```

```
/*    Function Name:    CalcNormals
```

```
 *    Description:    Calculates HVS weighted normals
```

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```

*   Arguments:  ctrl - compression control record
*
*               oct, sub, channel - co-ordinates
*
*               norms - pre-initialised normals
*
*   Returns:    weighted normals
*/

```

```
void CalcNormals(ctrl,oct,sub,channel,norms)
```

```

CompCtrl  ctrl;
int  oct, sub, channel;
double  norms[3];

{
    Video vid=ctrl->dst;
    int  norm, base_oct=oct+(vid->type==YUV &&
channel!=0?vid->trans.wavelet.space[0]-vid->trans.wavelet.space[1]:0)+(sub==0?1:0)
;

    for(norm=0;norm<3;norm++) {
        if (norm!=0) norms[norm] *= ctrl->quant_const;
        norms[norm] *=
ctrl->base_factors[base_oct]*(sub==3?ctrl->diag_factor:1.0);
        if (channel!=0) norms[norm] *= ctrl->chrome_factor;
        norms[norm] *=(double)(1<<vid->precision);
    }
}

```

```

/*   Function Name:    MakeDecisions
*
*   Description:    Decide on new compression mode from block values
*
*   Arguments:    old, new, pro - block values
*
*               zero - zero flag for new block
*
*               norms - HVS normals

```

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```

*           mode - current compression mode
*           decide - comparison algorithm
*   Returns:   new compression mode
*/

```

```

int   MakeDecisions(old,new,pro,zero,norms,mode,decide)

```

```

Block new, old, pro;

```

```

Boolean   zero;

```

```

double    norms[3];

```

```

int   mode, decide;

```

```

{

```

```

    Block zero_block={{0,0},{0,0}};

```

```

    int   new_mode, np=Decide(new,pro,decide), no=Decide(new,old,decide);

```

```

    if (np<no && (double)no>DecideDouble(norms[mode]==STILL?1:2],decide)
    && !zero)

```

```

        new_mode=mode==STILL ||

```

```

(double)Decide(old,zero_block,decide)<=DecideDouble(norms[1],decide)?STILL:SEND;

```

```

    else new_mode=mode==SEND && np<no && zero?VOID:STOP;

```

```

    return(new_mode);

```

```

}

```

```

int   MakeDecisions2(old,new,pro,lev,zero,norms,mode,decide)

```

```

Block new, old, pro, lev;

```

```

Boolean   zero;

```

```

double    norms[3];

```

```

int   mode, decide;

```

```

{

```

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```

Block zero_block={{0,0},{0,0}};
int  new_mode=mode==STILL || BlockZero(old)?STILL:SEND,
      np=Decide(new,pro,decide), no=Decide(new,old,decide);

if (new_mode==STILL) new_mode=np>no || zero ||
BlockZero(lev)?STOP:STILL;
else new_mode=zero && np<no?VOID:np>no ||
Decision(new,old,norms[2],decide) || BlockZero(lev)?STOP:SEND;
return(new_mode);
}

```

```

/*  Function Name:      UpdateCoeffs
*   Description:      Encode proposed values and write data
*   Arguments:      pro, lev, addr - proposed block, levels and addresses
*                   z, channel, oct - co-ordinates
*                   ctrl - compression control record
*                   hist - history record
*   Returns:      alters ctrl->dst->data[channel][z][addr[]]
*/

```

```
void UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist)
```

```

Block pro, lev, addr;
int  z, channel, oct;
CompCtrl ctrl;
Hist hist;

```

```

{
    int  X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        int  bits=Huffman(lev[X][Y]),

```

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```

        level = abs(lev[X][Y]);

    ctrl->dst->data[channel][z][addr[X][Y]] = (short)pro[X][Y];
    hist->coeff[level > 128?128:level] ++;
    hist->bits += bits;
    hist->octbits[channel][oct] += bits;
    if (ctrl->bin_switch) {
        unsigned char    *bytes = HuffCode(lev[X][Y]);

        bwrite(bytes, bits, ctrl->bfp);
        XtFree(bytes);
    }
}

/*  Function Name:    SendTree
 *  Description:    Encode tree blocks
 *  Arguments:    prev_mode - compression mode
 *                x, y, z, oct, sub, channel - co-ordinates
 *                ctrl - compression control record
 *                hist - history records
 *                empty - token mode
 *                branch - tree branch number
 *  Returns:    active block indicator
 */

```

Boolean SendTree(prev_mode, x, y, z, oct, sub, channel, ctrl, hist, empty, branch)

int prev_mode, x, y, z, oct, sub, channel, *empty, branch;

CompCtrl ctrl;

Hist hist;

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```

{
    Block addr, old, new, pro, lev;
    int    new_mode, X, Y;
    double

norms[3] = {ctrl->quant_const, ctrl->thresh_const, ctrl->cmp_const}; /* quant, thresh,
compare */
    Boolean    active = False;

    ReadBlock(new, old, addr, x, y, z, oct, sub, channel, ctrl);
    if (prev_mode != VOID) {
        Boolean    zero;

        CalcNormals(ctrl, oct, sub, channel, norms);
        zero = Proposed(pro, lev, old, new, ctrl->decide, norms);
    /*
new_mode = MakeDecisions(old, new, pro, zero, norms, prev_mode, ctrl->decide); */

new_mode = MakeDecisions2(old, new, pro, lev, zero, norms, prev_mode, ctrl->decide);
        switch(new_mode) {
            case STOP:

/*SendToken(prev_mode == STILL?ZERO_STILL:BLOCK_SAME, channel, sub, oct, ctrl, h
ist, empty, branch); */

                SendToken(prev_mode == STILL ||
BlockZero(old)?ZERO_STILL:BLOCK_SAME, channel, sub, oct, ctrl, hist, empty, branch);
                break;
            case STILL:
            case SEND:
                active = True;

/*SendToken(prev_mode == STILL?NON_ZERO_STILL:BLOCK_CHANGE, channel, sub
, oct, ctrl, hist, empty, branch); */

```

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```

        SendToken(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE,channel,sub,oct,ctrl,hist,empty,
branch);

        UpdateCoeffs(pro,lev,addr,z,channel,oct,ctrl,hist);
        break;

    case VOID:
        SendToken(ZERO_VID,channel,sub,oct,ctrl,hist,empty,branch);
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        break;
    }
} else {
    if (BlockZero(old)) new_mode=STOP;
    else {
        ZeroCoeffs(ctrl->dst->data[channel][z],addr);
        new_mode=VOID;
    }
}

if (oct>0 && new_mode!=STOP) {
    int    mt=OCTAVE_EMPTY, full=FULL;

    Dprintf("x=%d, y=%d, oct=%d sub=%d mode
%d\n",x,y,oct,sub,new_mode);
    for(Y=0;Y<2;Y++) for(X=0;X<2;X++)

(void)SendTree(new_mode,x*2+X,y*2+Y,z,oct-1,sub,channel,ctrl,hist,&mt,X+2*Y);
    if (mt==OCTAVE_EMPTY && new_mode!=VOID)
SendToken(OCT_ZERO,channel,sub,oct,ctrl,hist,&full,0);
}

return(active);
}

/*    Function Name:    SendLPF

```

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```

*   Description:  Encode LPF sub-band
*   Arguments:   mode - compression mode
*               z -   frame number
*               ctrl - compression control record
*               hist - history records
*   Returns:     encodes data
*/

```

```
void SendLPF(mode,z,ctrl,hist)
```

```
CompCtrl  ctrl;
```

```
int  mode, z;
```

```
Hist  hist;
```

```
{
```

```
Block new, old, pro, lev, addr;
```

```
int  channel, channels=ctrl->src->type==MONO?1:3, x, y, full=FULL,
```

```
octs_lum=ctrl->src->trans.wavelet.space[0],
```

```
size[2]={Size(ctrl->src,0,0)>>octs_lum+1,Size(ctrl->src,0,1)>>octs_lum+1};
```

```
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
```

```
int  empty=LPF_EMPTY;
```

```
for(channel=0;channel<channels;channel++) {
```

```
int  octs=ctrl->src->trans.wavelet.space[ctrl->src->type==YUV
```

```
&& channel!=0?1:0],
```

```
new_mode, X, Y, step, value, bits=0;
```

```
double
```

```
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
```

```
CalcNormals(ctrl,octs-1,0,channel,norms);
```

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```

    step = norms[0] < 1.0 ? 1 : (int) norms[0];
    for(bits=0,
value=((1 < < 8+ctrl->dst->precision)-1)/step; value!=0; bits++)
    value = value > > 1;
    ReadBlock(new,old,addr,x,y,z,octs-1,0,channel,ctrl);

    /* Proposed */
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));

    /* MakeDecisions */

new_mode=mode==STILL?STILL:Decision(new,old,norms[2],ctrl->decide) ||
BlockZero(lev)?STOP:SEND;

    switch(new_mode) {
    case SEND:
        SendToken(LPF_NON_ZERO,channel,0,octs,ctrl,hist,&empty,0);
        UpdateCoeffs(pro,lev,addr,z,channel,octs,ctrl,hist);
        break;
    case STILL:
        for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
            ctrl->dst->data[channel][z][addr[X][Y]]=(short)pro[X][Y];
            hist->bits+=bits;
            hist->octbits[channel][octs]+=bits;
            if (ctrl->bin_switch) {
                unsigned char *bytes=CodeInt(lev[X][Y],bits);

                bwrite(bytes,bits,ctrl->bfp);
                XtFree(bytes);
            }
        }
    }

```

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```

        }
        break;
    case STOP:
        SendToken(LPF_ZERO,channel,0,octs,ctrl,hist,&empty,0);
        break;
    }
}

if (mode!=STILL && empty==LPF_EMPTY)
SendToken(LPF_LOC_ZERO,channel,0,octs_lum,ctrl,hist,&full,0);
}

hist->lpf=hist->bits;
}

```

```

/*  Function Name:    LookAhead
 *  Description:    Examine base of tree to calculate new quantizer value
 *  Arguments:    z - frame number
 *
 *                  ctrl - compression control record
 *                  hist - history records
 *  Returns:    calculates new ctrl->quant_const
 */

```

```
void LookAhead(z,ctrl,hist)
```

```
CompCtrl    ctrl;
```

```
int    z;
```

```
Hist    hist;
```

```
{
```

```

    int    x, y, sub, index, thresh[HISTO], decide=ctrl->decide, act,
           taract=Feedback(hist,z,ctrl->feedback),
           octs=ctrl->src->trans.wavelet.space[0],

```

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```

size[2]={Size(ctrl->src,0,0)>>1+octs,Size(ctrl->src,0,1)>>1+octs};
    Block new, old, addr;
    double      old_quant=ctrl->quant_const;

    ctrl->quant_const=1.0;
    for(index=0;index<HISTO;index++) thresh[index]=0;
    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++)
for(sub=1;sub<4;sub++) {
        double      q_thresh[3],
norms[3]={ctrl->quant_const,ctrl->thresh_const,ctrl->cmp_const};
        Block zero_block={{0,0},{0,0}};

        ReadBlock(new,old,addr,x,y,z,octs-1,sub,0,ctrl);
        CalcNormals(ctrl,octs-1,sub,0,norms);

q_thresh[1]=(double)Decide(new,zero_block,decide)/DecideDouble(norms[1],decide);

q_thresh[2]=(double)Decide(new,old,decide)/DecideDouble(norms[2],decide);
        if (BlockZero(old)) q_thresh[0]=q_thresh[1];
        else q_thresh[0]=q_thresh[2]<q_thresh[1]?q_thresh[2]:q_thresh[1];
        if (ctrl->decide==SIGSQR) q_thresh[0]=sqrt(q_thresh[0]);

index=(int)((q_thresh[0]-old_quant+HISTO_DELTA)*HISTO/(HISTO_DELTA*2));
        index=index<0?0:index>HISTO-1?HISTO-1:index;
        thresh[index]++;
    }
    for(index=HISTO-1, act=0;index>=0 && act<taract;index--)
act+=thresh[index];

ctrl->quant_const=(double)(index+1)*HISTO_DELTA*2.0/HISTO+old_quant-HISTO_
DELTA;

ctrl->quant_const=ctrl->quant_const<0.0?0.0:ctrl->quant_const;

```

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```

    Dprintf("Target bits %d act %d (real %d) adjust q_const to
%3.2f\n", hist[z].target, taract, act, ctrl->quant_const);
    hist[z].q_const = ctrl->quant_const;
    ctrl->quant_const = Filter(hist, z, ctrl->feedback, ctrl->filter);
    Dprintf("Post filtering q_const to %3.2f\n", ctrl->quant_const);
    if (ctrl->bin_switch) {
        unsigned char *bytes = CodeInt(index + 1 - HISTO/2, HISTO_BITS);

        bwrite(bytes, HISTO_BITS, ctrl->bfp);
        XtFree(bytes);
    }
}

```

```

/*  Function Name:    CompressStats
*   Description:    Compile compression statistics
*   Arguments:    ctrl - compression control record
*                  hist - history records
*   Returns:    plot graphs
*/

```

```
void CompressStats(ctrl, hist)
```

```
CompCtrl    ctrl;
```

```
Hist    hist;
```

```
{
```

```
    FILE *fp_token, *fp_coeff, *fp_log, *fopen();
```

```
    char file_name[STRLEN];
```

```
    int channel, z, i, sigma;
```

```
    sprintf(file_name, "%s%s/%s.token%s\0", global->home, PLOT_DIR, ctrl->stats_name, P
```

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LOT_EXT);

fp_token=fopen(file_name,"w");

```
sprintf(file_name,"%s%s/%s.coeff%s\0",global->home,PLOT_DIR,ctrl->stats_name,PL
OT_EXT);
```

fp_coeff=fopen(file_name,"w");

```
sprintf(file_name,"%s%s/%s.log%s\0",global->home,PLOT_DIR,ctrl->stats_name,PLO
T_EXT);
```

fp_log=fopen(file_name,"w");

fprintf(fp_token,"\Tokens %s\n",ctrl->name);

for(i=0;i<TOKENS;i++) {

sigma=0;

for(z=0;z<ctrl->src->size[2];z++) sigma+=hist[z].token[i];

fprintf(fp_token,"%d %d\n",i,sigma);

}

fprintf(fp_coeff,"\Coeffs %s\n",ctrl->name);

for(i=0;i<129;i++) {

sigma=0;

for(z=0;z<ctrl->src->size[2];z++) sigma+=hist[z].coeff[i];

fprintf(fp_coeff,"%d %d\n",i,sigma);

}

for(i=0;i<5;i++) {

String titles[5]={"treebits","activity","quant","bits","ratio"};

fprintf(fp_log,"\n"%s\n",titles[i]);

for(z=0;z<ctrl->src->size[2];z++)

switch(i) {

case 0: fprintf(fp_log,"%d %d\n",z,hist[z].bits-hist[z].lpf);

break;

case 1: fprintf(fp_log,"%d %d\n",z,hist[z].activity);

break;

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```

        case 2: fprintf(fp_log, "%d %f\n", z, hist[z].q_const);
                break;
        case 3:      fprintf(fp_log, "%d %d\n", z, hist[z].bits);
                break;
        case 4:      fprintf(fp_log, "%d
%f\n", z, (double)(hist[z].bits - (z == 0 ? hist[z].lpf : 0)) / (double)hist[z].activity);
                break;
    }
}

for(channel=0; channel < (ctrl->src->type == MONO ? 1 : 3); channel++) {
    int    octs = ctrl->src->trans.wavelet.space[ctrl->src->type == YUV
&& channel != 0 ? 1 : 0];

    for(i=0; i <= octs; i++) {
        fprintf(fp_log, "\n\nchannel %d oct %d\n", channel, i);
        for(z=0; z < ctrl->src->size[2]; z++)
            fprintf(fp_log, "%d %d\n", z, hist[z].octbits[channel][i]);
    }
}

fclose(fp_token); fclose(fp_coeff); fclose(fp_log);
}

```

```

/*      Function Name:      CopyFrame
*      Description:      Copy frame or zero
*      Arguments:      vid - video
*                      from, to - source and destination frame numbers
*                      zero - zero out flag
*      Returns:      alters video->data
*/

```

```
void CopyFrame(vid, from, to, zero)
```

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```

Video vid;
int    from, to;
Boolean    zero;

{
    int    i, channel;

    for(channel=0;channel < (vid->type == MONO?1:3);channel++) {
        int    size = Size(vid,channel,0)*Size(vid,channel,1);

        for(i=0;i < size;i++)
            vid->data[channel][to][i] = zero?0:vid->data[channel][from][i];
    }
}

```

```

/*  Function Name:    CompressFrame
*   Description:    Compress a Frame
*   Arguments:    ctrl - compression control record
*                  z - frame number
*                  hist - history records
*                  target - target bits
*/

```

```

void    CompressFrame(ctrl,z,hist,target)

```

```

CompCtrl    ctrl;
int    z, target;
Hist    hist;

```

```

{
    Video    src=ctrl->src, dst=ctrl->dst;
    int    sub, channel, x, y, mode=ctrl->stillvid || z==0?STILL:SEND,

```

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```

    octs_lum=src->trans.wavelet.space[0],

size[2]={Size(src,0,0)>>1+octs_lum,Size(src,0,1)>>1+octs_lum};

NewFrame(dst,z);
CopyFrame(dst,z-1,z,ctrl->stillvid || z==0);
GetFrame(src,z);
hist[z].target=target;
if (z!=0 && ctrl->auto_q) LookAhead(z,ctrl,hist);
SendLPF(mode,z,ctrl,&hist[z]);
Dprintf("LPF bits %d\n",hist[z].lpf);
hist[z].q_const=ctrl->quant_const;
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
    int    empty=EMPTY, full=FULL;

    for(channel=0;channel<(dst->type==MONO?1:3);channel++) {
        int    octs=src->trans.wavelet.space[src->type==YUV &&
channel!=0?1:0];

        for(sub=1;sub<4;sub++) {
            Boolean
active=SendTree(mode,x,y,z,octs-1,sub,channel,ctrl,&hist[z],&empty,0);

            hist[z].activity+=channel==0 && active;
        }
        switch(empty) {
        case FULL:
            empty=CHANNEL_EMPTY;
            break;
        case CHANNEL_EMPTY:
            SendToken(CHANNEL_ZERO,channel,sub,octs-1,ctrl,&hist[z],&full,0);
            break;

```

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```

    }
}
    if (empty == EMPTY)
SendToken(LOCAL_ZERO,channel,sub,octs_lum-1,ctrl,&hist[z],&full,0);
    }
    Dprintf(" Activity: %d\n",hist[z].activity);
    FreeFrame(src,z);
}

```

```

/*  Function Name:      SkipFrame
*   Description:  Shuffle frame data as if current frame was skipped
*   Arguments:   vid - video
*                z - frame number
*   Returns:     alters vid->data
*/

```

```

void  SkipFrame(vid,z)

```

```

Video vid;

```

```

int    z;

```

```

{
    NewFrame(vid,z);
    CopyFrame(vid,z-1,z,False);
    if (z > 1) {
        GetFrame(vid,z-2);
        CopyFrame(vid,z-2,z-1,False);
        FreeFrame(vid,z-2);
    }
}

```

```

/*  Function Name:      CompressCtrl

```

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```

*   Description:  Perform KLICS on a video
*   Arguments:   w - Xaw widget
*
*                   closure - compression control record
*                   call_data - NULL
*   Returns:     compressed video
*/

```

```
void CompressCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    CompCtrl  ctrl=(CompCtrl)closure;
```

```
    int       sigma_bits, frame_count, z, i, buffer=0, frames=ctrl->src->size[2],
```

```
             bpf_in=(64000*ctrl->bitrate)/ctrl->src->rate,
```

```
             bpf_out=(int)((double)(64000*ctrl->bitrate)/ctrl->fps);
```

```
    FILE      *fopen();
```

```
    char      file_name[STRLEN];
```

```
    HistRec   hist[frames];
```

```
    Message   msg=NewMessage(NULL,60);
```

```
    msg->rows=frames>10?11:frames+(frames==1?0:1); msg->cols=30;
```

```
    if (global->batch==NULL) {
```

```
        XtCallbackRec  callbacks[]={
```

```
            {CloseMessage,(caddr_t)msg}, {NULL,NULL},
```

```
        };
```

```
    MessageWindow(FindWidget("frm_compress",w),msg,"KLICS",True,callbacks);
```

```
}
```

```
    Dprintf("CompressCtrl\n");
```

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```

    if (ctrl->src->type == YUV &&
(ctrl->src->trans.wavelet.space[0] != ctrl->src->trans.wavelet.space[1] + ctrl->src->U
Vsample[0] || ctrl->src->UVsample[0] != ctrl->src->UVsample[1])) {
        Eprintf("Y-UV octaves mis-matched. Check UV-sample");
        return;
    }

    ctrl->dst = CopyHeader(ctrl->src);
    strcpy(ctrl->dst->name, ctrl->name);
    if (ctrl->dst->disk) SaveHeader(ctrl->dst);
    if (ctrl->bin_switch) {

sprintf(file_name, "%s%s/%s%s\0", global->home, KLICS_DIR, ctrl->bin_name, KLICS_
EXT);

        ctrl->bfp = bopen(file_name, "w");
        /* Write some sort of header */
        WriteKlicsHeader(ctrl);
    }

    for(z=0; z < frames; z++) {
        hist[z].bits=0;
        hist[z].lpf=0;
        hist[z].activity=0;
        hist[z].target=0;
        for(i=0; i < 5; i++) hist[z].octbits[0][i]=0;
        for(i=0; i < 5; i++) hist[z].octbits[1][i]=0;
        for(i=0; i < 5; i++) hist[z].octbits[2][i]=0;
        for(i=0; i < TOKENS; i++) hist[z].token[i]=0;
        for(i=0; i < 129; i++) hist[z].coeff[i]=0;
        hist[z].q_const=0.0;
    }

    for(z=0; z < frames; z++) {
        if (z == 0 || !ctrl->buf_switch) {
            CompressFrame(ctrl, z, hist, bpf_out);

```

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```

        buffer = 3200*ctrl->bitrate + bpf_in;
    } else {
        Boolean    no_skip;

        buffer -= bpf_in;
        buffer = buffer < 0 ? 0 : buffer;
        no_skip = buffer < 6400*ctrl->bitrate; /* H.261 buffer size */
        if (ctrl->bin_switch) bwrite(&no_skip, 1, ctrl->bfp);
        if (no_skip) {
            CompressFrame(ctrl, z, hist, bpf_out/* + bpf_out/2 - buffer */);
            buffer += hist[z].bits;
        } else SkipFrame(ctrl->dst, z);
    }
    if (z > 0) {
        SaveFrame(ctrl->dst, z-1);
        FreeFrame(ctrl->dst, z-1);
    }
    Mprintf(msg, "%s%03d: %d
bits\n", ctrl->dst->name, z + ctrl->src->start, hist[z].bits);
    Mflush(msg);
}
SaveFrame(ctrl->dst, ctrl->src->size[2]-1);
FreeFrame(ctrl->dst, ctrl->src->size[2]-1);
if (ctrl->bin_switch) { bflush(ctrl->bfp); bclose(ctrl->bfp); }
if (ctrl->stats_switch) CompressStats(ctrl, hist);
Dprintf("Compression Complete\n");
sigma_bits = 0, frame_count = 0;
for (z = 0; z < ctrl->src->size[2]; z++) {
    sigma_bits += hist[z].bits;
    if (hist[z].bits != 0) frame_count++;
}
if (ctrl->buf_switch) {

```

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```

        Dprintf("Buffer contains %d bits\n",buffer-bpf_in);
        Dprintf("Frame Rate %4.1f
Hz\n", (double)(ctrl->src->rate*(frame_count-1))/(double)(ctrl->src->size[2]-1));
    }
    if (frames > 1) {
        Mprintf(msg, "Total: %d bits\n", sigma_bits);
        Mflush(msg);
    }
    ctrl->dst->next=global->videos;
    global->videos=ctrl->dst;
}

/*  Function Name:      BatchCompCtrl
 *
 *  Description:   Batch interface to CompressCtrl
 */

void  BatchCompCtrl(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    CompCtrl  ctrl=(CompCtrl)closure;

    if (ctrl->src == NULL) ctrl->src=FindVideo(ctrl->src_name,global->videos);
    CompressCtrl(w,closure,call_data);
}

/*  Function Name:      InitCompCtrl
 *
 *  Description:   Initialise the compression control record
 *
 *  Arguments:   name - name of the source video
 *
 *  Returns:      compression control record

```


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*/

```
CompCtrl  InitCompCtrl(name)
```

```
String name;
```

```
{
```

```
    CompCtrl  ctrl=(CompCtrl)MALLOC(sizeof(CompCtrlRec));
```

```
    int      i;
```

```
    ctrl->decide = SIGABS;
```

```
    ctrl->feedback=4;
```

```
    ctrl->filter=0;
```

```
    ctrl->stillvid=True;
```

```
    ctrl->stats_switch=False;
```

```
    ctrl->auto_q=True;
```

```
    ctrl->buf_switch=True;
```

```
    ctrl->bin_switch=False;
```

```
    ctrl->cmp_const=0.9;
```

```
    ctrl->thresh_const=0.6;
```

```
    ctrl->quant_const=8.0;
```

```
    ctrl->fps=30.0;
```

```
    ctrl->bitrate=1;
```

```
    for(i=0;i<5;i++) {
```

```
        double      defaults[5]={1.0,0.32,0.16,0.16,0.16};
```

```
        ctrl->base_factors[i]=defaults[i];
```

```
    }
```

```
    ctrl->diag_factor=1.4142136;
```

```
    ctrl->chrome_factor=2.0;
```

```
    strcpy(ctrl->src_name,name);
```

```
    strcpy(ctrl->name,name);
```

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```

        strcpy(ctrl->stats_name,name);
        strcpy(ctrl->bin_name,name);
        return(ctrl);
    }

/*    Function Name:      Compress
 *    Description:  X Interface to CompressCtrl
 */

#define    COMP_ICONS    25
#define    VID_ICONS    15

void    Compress(w,closure,call_data)

Widget        w;
caddr_t        closure, call_data;

{
    Video video=(Video)closure;
    CompCtrl    ctrl=InitCompCtrl(video->name);
    int    i, space=video->trans.wavelet.space[0]+1;
    NumInput    num_inputs=(NumInput)MALLOC(2*sizeof(NumInputRec));
    FloatInput    flt_inputs=(FloatInput)MALLOC(6*sizeof(FloatInputRec)),

oct_inputs=(FloatInput)MALLOC(space*sizeof(FloatInputRec));
    Message    msg=NewMessage(ctrl->name,NAME_LEN),
               msg_bin=NewMessage(ctrl->bin_name,NAME_LEN),
               msg_stats=NewMessage(ctrl->stats_name,NAME_LEN);
    XtCallbackRec    destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)num_inputs},
        {Free,(caddr_t)flt_inputs},

```

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```

    {Free,(caddr_t)oct_inputs},
    {CloseMessage,(caddr_t)msg},
    {CloseMessage,(caddr_t)msg_bin},
    {CloseMessage,(caddr_t)msg_stats},
    {NULL,NULL},
};

Widget      parent=FindWidget("frm_compress",XtParent(w)),
            shell=ShellWidget("klics",parent,SW_below,NULL,destroy_call),
            form=FormatWidget("klics_form",shell),

dec_shell=ShellWidget("klics_cng_dec",shell,SW_menu,NULL,NULL), dec_widgets[3],

filt_shell=ShellWidget("klics_cng_filt",shell,SW_menu,NULL,NULL), filt_widgets[2],
            widgets[COMP_ICONS], vid_widgets[VID_ICONS],
oct_widgets[space*2];

FormItem    items[]={
    {"klics_cancel","cancel",0,0,FW_icon,NULL},
    {"klics_confirm","confirm",1,0,FW_icon,NULL},
    {"klics_title","Compress a video",2,0,FW_label,NULL},
    {"klics_vid_lab","Video Name:",0,3,FW_label,NULL},
    {"klics_vid",NULL,4,3,FW_text,(String)msg},

    {"klics_stats_lab","Statistics:",0,4,FW_label,NULL},
    {"klics_stats",NULL,4,4,FW_yn,(String)&ctrl->stats_switch},
    {"klics_stats_name",NULL,7,4,FW_text,(String)msg_stats},
    {"klics_bin_lab","KLICS File:",0,6,FW_label,NULL},
    {"klics_bin",NULL,4,6,FW_yn,(String)&ctrl->bin_switch},

    {"klics_bin_name",NULL,10,6,FW_text,(String)msg_bin},
    {"klics_dec_lab","Decision:",0,9,FW_label,NULL},
    {"klics_dec_btn","SigmaAbs",4,9,FW_button,"klics_cng_dec"},
    {"klics_qn_float",NULL,0,12,FW_float,(String)&flt_inputs[0]},

```

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```

{"klics_qn_scroll",NULL,4,12,FW_scroll,(String)&flt_inputs[0]},

{"klics_th_float",NULL,0,14,FW_float,(String)&flt_inputs[1]},
{"klics_th_scroll",NULL,4,14,FW_scroll,(String)&flt_inputs[1]},
{"klics_cm_float",NULL,0,16,FW_float,(String)&flt_inputs[2]},
{"klics_cm_scroll",NULL,4,16,FW_scroll,(String)&flt_inputs[2]},
{"klics_ch_float",NULL,0,18,FW_float,(String)&flt_inputs[3]},

{"klics_ch_scroll",NULL,4,18,FW_scroll,(String)&flt_inputs[3]},
{"klics_di_float",NULL,0,20,FW_float,(String)&flt_inputs[4]},
{"klics_di_scroll",NULL,4,20,FW_scroll,(String)&flt_inputs[4]},
{"klics_oct_form",NULL,0,22,FW_form,NULL},
{"klics_vid_form",NULL,0,24,FW_form,NULL},
}, vid_items[]={
    {"klics_ic_lab","Image Comp:",0,0,FW_label,NULL},
    {"klics_ic",NULL,1,0,FW_yn,(String)&ctrl->stillvid},
    {"klics_tg_float",NULL,0,1,FW_float,(String)&flt_inputs[5]},
    {"klics_tg_scroll",NULL,1,1,FW_scroll,(String)&flt_inputs[5]},
    {"klics_px_int",NULL,0,3,FW_integer,(String)&num_inputs[0]},

    {"klics_px_down",NULL,1,3,FW_down,(String)&num_inputs[0]},
    {"klics_px_up",NULL,6,3,FW_up,(String)&num_inputs[0]},
    {"klics_auto_lab","Auto Quant:",0,5,FW_label,NULL},
    {"klics_auto",NULL,1,5,FW_yn,(String)&ctrl->auto_q},
    {"klics_buf_lab","Buffer:",0,8,FW_label,NULL},

    {"klics_buf",NULL,1,8,FW_yn,(String)&ctrl->buf_switch},
    {"klics_buf_btm","None",11,8,FW_button,"klics_cng_filt"},
    {"klics_hs_int",NULL,0,10,FW_integer,(String)&num_inputs[1]},
    {"klics_hs_down",NULL,1,10,FW_down,(String)&num_inputs[1]},
    {"klics_hs_up",NULL,14,10,FW_up,(String)&num_inputs[1]},
}, oct_items[2*space];

```

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```

MenuItem    dec_menu[] = {
    {"klics_dec_max", smeBSBObjectClass, "Maximum", NULL},
    {"klics_dec_abs", smeBSBObjectClass, "SigmaAbs", NULL},
    {"klics_dec_sqr", smeBSBObjectClass, "SigmaSqr", NULL},
}, filt_menu[] = {
    {"klics_filt_none", smeBSBObjectClass, "None", NULL},
    {"klics_filt_exp", smeBSBObjectClass, "Exp", NULL},
};

XtCallbackRec    callbacks[] = {
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {CompressCtrl, (caddr_t)ctrl},
    {Destroy, (caddr_t)shell},
    {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->stats_switch}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->bin_switch}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[0]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[1]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[2]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[3]}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[4]}, {NULL, NULL},
}, vid_call[] = {
    {ChangeYN, (caddr_t)&ctrl->stillvid}, {NULL, NULL},
    {FloatIncDec, (caddr_t)&flt_inputs[5]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[0]}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->auto_q}, {NULL, NULL},
    {ChangeYN, (caddr_t)&ctrl->buf_switch}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
    {NumIncDec, (caddr_t)&num_inputs[1]}, {NULL, NULL},
}, dec_call[] = {
    {SimpleMenu, (caddr_t)&ctrl->decide}, {NULL, NULL},

```

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```
{SimpleMenu,(caddr_t)&ctrl->decide}, {NULL,NULL},
{SimpleMenu,(caddr_t)&ctrl->decide}, {NULL,NULL},
}, flt_call[] = {
    {SimpleMenu,(caddr_t)&ctrl->filter}, {NULL,NULL},
    {SimpleMenu,(caddr_t)&ctrl->filter}, {NULL,NULL},
}, oct_call[2*space];
XFontStruct *font;
Arg args[1];

msg->rows=1; msg->cols=NAME_LEN;
msg_stats->rows=1; msg_stats->cols=NAME_LEN;
msg_bin->rows=1; msg_bin->cols=NAME_LEN;
ctrl->src=(Video)closure;

flt_inputs[0].format="Quant: %4.1f";
flt_inputs[0].max=10;
flt_inputs[0].min=0;
flt_inputs[0].value= &ctrl->quant_const;

flt_inputs[1].format="Thresh: %4.1f";
flt_inputs[1].max=10;
flt_inputs[1].min=0;
flt_inputs[1].value= &ctrl->thresh_const;

flt_inputs[2].format="Comp: %4.1f";
flt_inputs[2].max=10;
flt_inputs[2].min=0;
flt_inputs[2].value= &ctrl->cmp_const;

flt_inputs[3].format="Chrome: %4.1f";
flt_inputs[3].max=5;
flt_inputs[3].min=1;
```

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```
flt_inputs[3].value = &ctrl->chrome_factor;
```

```
flt_inputs[4].format="Diag: %4.1f";
```

```
flt_inputs[4].max=2.0;
```

```
flt_inputs[4].min=1.0;
```

```
flt_inputs[4].value = &ctrl->diag_factor;
```

```
flt_inputs[5].format="Target: %4.1f";
```

```
flt_inputs[5].max=30.0;
```

```
flt_inputs[5].min=10.0;
```

```
flt_inputs[5].value = &ctrl->fps;
```

```
num_inputs[0].format="px64k: %1d";
```

```
num_inputs[0].max=8;
```

```
num_inputs[0].min=1;
```

```
num_inputs[0].value = &ctrl->bitrate;
```

```
num_inputs[1].format="History: %1d";
```

```
num_inputs[1].max=8;
```

```
num_inputs[1].min=1;
```

```
num_inputs[1].value = &ctrl->feedback;
```

```
for(i=0;i < space;i++) {
```

```
    String format=(char *)MALLOC(20);
```

```
    if (i==0) sprintf(format,"Octave LPF: %%4.2f");
```

```
    else sprintf(format,"Octave %3d: %%4.2f",space-i-1);
```

```
    oct_inputs[i].format=format;
```

```
    oct_inputs[i].max=1.0;
```

```
    oct_inputs[i].min=0.0;
```

```
    oct_inputs[i].value = &ctrl->base_factors[space-i-1];
```

```
    oct_items[2*i].name="klics_oct_float";
```

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```

    oct_items[2*i].contents=NULL;
    oct_items[2*i].fromHoriz=0;
    oct_items[2*i].fromVert=i==0?0:2*i-1;
    oct_items[2*i].type=FW_float;
    oct_items[2*i].hook=(String)&oct_inputs[i];
    oct_items[2*i+1].name="klics_oct_scroll";
    oct_items[2*i+1].contents=NULL;
    oct_items[2*i+1].fromHoriz=1;
    oct_items[2*i+1].fromVert=i==0?0:2*i-1;
    oct_items[2*i+1].type=FW_scroll;
    oct_items[2*i+1].hook=(String)&oct_inputs[i];
    oct_call[2*i].callback=FloatIncDec;
    oct_call[2*i].closure=(String)&oct_inputs[i];
    oct_call[2*i+1].callback=NULL;
    oct_call[2*i+1].closure=NULL;
}

FillForm(form,COMP_ICONS-(video->size[2]>1?0:1),items,widgets,callbacks);
FillForm(widgets[23],2*space,oct_items,oct_widgets,oct_call);
FillMenu(dec_shell,THREE,dec_menu,dec_widgets,dec_call);
font=FindFont(widgets[12]);

XtSetArg(args[0],XtNwidth,2+TextWidth(0,"Maximum\nSigmaAbs\nSigmaSqr",font));
XtSetValues(widgets[12],args,ONE);
if (video->size[2]>1) {
    FillForm(widgets[24],VID_ICONS,vid_items,vid_widgets,vid_call);
    FillMenu(filt_shell,TWO,filt_menu,filt_widgets,filt_call);
    font=FindFont(vid_widgets[11]);
    XtSetArg(args[0],XtNwidth,2+TextWidth(0,"None\nExp",font));
    XtSetValues(vid_widgets[11],args,ONE);
}
XtPopup(shell,XtGrabExclusive);
}

```


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source/KlicsSA.c

/*

Full still/video Knowles-Lewis Image Compression System utilising HVS
properties
and delta-tree coding

Stand-Alone version uses fixed image format and static data structures

*/

#include "KlicsSA.h"

#include <math.h>

extern void Convolve();

/* useful X definitions */

typedef char Boolean;

#define True 1

#define False 0

#define String char*

/* token modes (empty) */

#define EMPTY 0

#define CHANNEL_EMPTY 1

#define OCTAVE_EMPTY 2

#define LPF_EMPTY 3

#define FULL 4

/* Function Name: AccessSA

* Description: Find index address from co-ordinates

* Arguments: x, y - (x,y) co-ordinates

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```

*           oct, sub, channel - octave, sub-band and channel co-ordinates
*   Returns: index into data[channel][index]
*/

```

```
int   AccessSA(x,y,oct,sub,channel)
```

```
int   x, y, oct, sub, channel;
```

```
{
```

```
return(((x < 1)+(sub > 1)+(SA_WIDTH > (channel == 0?0:1))*((y < 1)+(1&sub)
)) < oct);
```

```
}
```

```
/*   Function Name:   DecideSA
```

```
*   Description:   Calculate value representing the difference between new and old
blocks
```

```
*   Arguments:   new, old - blocks to compare
```

```
*   Returns:     difference value
```

```
*/
```

```
int   DecideSA(new,old)
```

```
Block new, old;
```

```
{
```

```
int   X, Y, sigma=0;
```

```
for(X=0;X < BLOCK;X++) for(Y=0;Y < BLOCK;Y++)
```

```
sigma += abs(new[X][Y]-old[X][Y]);
```

```
return(sigma);
```

```
}
```

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```
/*  Function Name:    DecideDoubleSA
 *  Description:      Calculates normal w.r.t differencing algorithm
 *  Arguments:        norm - normal value
 *  Returns:          new normal value
 */
```

```
double    DecideDoubleSA(norm)
```

```
double    norm;
```

```
{
    return(4.0*norm);
}
```

```
Boolean    DecisionSA(new,old,norm)
```

```
Block new, old;
```

```
double    norm;
```

```
{
    return(((double)DecideSA(new,old) <= DecideDoubleSA(norm));
}
```

```
/*  Function Name:    HuffmanSA
```

```
 *  Description:      Calculates the number of bits for the Huffman code representing
level
```

```
 *  Arguments:        level - level to be encoded
```

```
 *  Returns:          number of bits in codeword
```

```
*/
```

```
int    HuffmanSA(level)
```

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```
int    level;
```

```
{
    return(level == 0?2:(abs(level) < 3?3:1 + abs(level)));
}
```

```
/*    Function Name:    HuffCodeSA
 *    Description:    Generates Huffman code representing level
 *    Arguments:    level - level to be encoded
 *    Returns:    coded bits in char's
 */
```

```
unsigned char *HuffCodeSA(level)
```

```
int    level;
```

```
{
    unsigned char *bytes=(unsigned char *)MALLOC((7+Huffman(level))/8);

    bytes[0]=(abs(level) < 3?abs(level):3)|(level < 0?4:0);
    if (abs(level) > 2) {
        int    index=(7+Huffman(level))/8-1;

        bytes[index]=bytes[index]|(1 < < (Huffman(level)-1)%8);
    }
    return(bytes);
}
```

```
unsigned char *CodeIntSA(number,bits)
```

```
int    number, bits;
```

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```

{
    int    len=(7+bits)/8;
    unsigned char *bytes=(unsigned char *)MALLOC(len);
    int    byte;

    for(byte=0;byte<len;byte++) {
        bytes[byte]=0xff&number;
        number=number>>8;
    }
    return(bytes);
}

int    ReadIntSA(bits,bfp)

int    bits;
Bits   bfp;

{
    int    len=(7+bits)/8;
    unsigned char bytes[len];
    int    byte, number=0;

    bread(bytes,bits,bfp);
    for(byte=0;byte<len;byte++)
        number=number|(((int)bytes[byte]<<byte*8);
    number=(number<<sizeof(int)*8-bits)>>sizeof(int)*8-bits;
    return(number);
}

/*  Function Name:      HuffReadSA
*
*  Description:  Read Huffman encoded number from binary file
*
*  Arguments:    bfp - binary file pointer

```

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```

*   Returns:      decoded level
*/

int   HuffReadSA(bfp)

Bits  bfp;

{
    int   value;
    unsigned char   byte;
    Boolean   negative = False;

    bread(&byte, 2, bfp);
    value = (int)byte;
    if (byte == '\0') return(0);
    else {
        bread(&byte, 1, bfp);
        negative = (byte != '\0');
    }
    if (value < 3) return(negif(negative, value));
    for(byte = '\0'; byte == '\0'; value++) bread(&byte, 1, bfp);
    return(negif(negative, value-1));
}

/*   Function Name:      QuantizeSA
*   Description:  RM8 style quantizer
*   Arguments:  data - unquantised number
*               q - quantizing divisor
*               level - quantised to level
*   Returns:      quantized data & level
*/

```

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```

int    QuantizeSA(data,q,level)

int    data, q, *level;

{
    int    mag_level=abs(data)/q;

    *level=negif(data<0,mag_level);
    return(negif(data<0,mag_level*q+(mag_level!=0?(q-1)>>1:0)));
}

```

```

/*    Function Name:    ProposedSA
*
*    Description:    Calculates proposed block values
*
*    Arguments:    pro - proposed block
*
*                  lev - proposed block quantized levels
*
*                  old, new - old and new block values
*
*                  norms - HVS normals
*
*    Returns:    new == 0, proposed values (pro) and levels (lev)
*/

```

```

Boolean    ProposedSA(pro,lev,old,new,norms)

```

```

Block pro, lev, old, new;

```

```

double    norms[3];

```

```

{
    Block zero_block={{0,0},{0,0}};
    int    X, Y, step=norms[0]<1.0?1:(int)norms[0];
    Boolean    zero=DecisionSA(new,zero_block,norms[1]);

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

```

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```

pro[X][Y]=zero?0:old[X][Y]+Quantize(new[X][Y]-old[X][Y],step,&(lev[X][Y]));
    return(zero);
}

```

```

/*  Function Name:    ZeroCoeffsSA
 *  Description:      Zero out video data
 *  Arguments:        data - image data
 *                    addr - addresses
 *  Returns:          zeros data[addr[][]]
 */

```

```

void ZeroCoeffsSA(data,addr)

```

```

short *data;

```

```

Block addr;

```

```

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        data[addr[X][Y]]=0;
}

```

```

/*  Function Name:    BlockZeroSA
 *  Description:      Test if all block values are zero
 *  Arguments:        block - block under test
 *  Returns:          block==0
 */

```

```

Boolean    BlockZeroSA(block)

```

```

Block block;

```


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```

{
    int    X, Y;
    Boolean    zero = True;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)
        if (block[X][Y]!=0) zero = False;
    return(zero);
}

```

```

/*    Function Name:    SendTokenSA
*    Description:    Increments token frequency
*    Arguments:    token - token to be transmitted
*                  channel, sub, oct - co-ordinates
*                  bfp - binary file pointer
*                  empty - zero state {EMPTY | CHANNEL_EMPTY |
OCTAVE_EMPTY | LPF_EMPTY | FULL}
*                  branch - branch of tree (0-3)
*    Returns:    encodes token
*/

```

```

void    SendTokenSA(token,channel,sub,oct,bfp,empty,branch)

```

```

int    token, channel, sub, oct, *empty, branch;
Bits    bfp;

```

```

{
    int    full=FULL, i;
    String
token_name[TOKENS]={"ZERO_STILL","NON_ZERO_STILL","BLOCK_SAME","ZE
RO_VID","BLOCK_CHANGE",

"LOCAL_ZERO","LOCAL_NON_ZERO","CHANNEL_ZERO","CHANNEL_NON_ZE

```

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RO", "OCT_ZERO", "OCT_NON_ZERO",

"LPF_ZERO", "LPF_NON_ZERO", "LPF_LOC_ZERO", "LPF_LOC_NON_ZERO"};

switch(*empty) {

case EMPTY:

if (token! = ZERO_STILL && token! = BLOCK_SAME) {

SendTokenSA(LOCAL_NON_ZERO, channel, sub, oct, bfp, &full, branch);

for(i=0; i < channel; i++)

SendTokenSA(CHANNEL_ZERO, i, sub, oct, bfp, &full, branch);

*empty = CHANNEL_EMPTY;

SendTokenSA(token, channel, sub, oct, bfp, empty, branch);

}

break;

case CHANNEL_EMPTY:

if (token! = ZERO_STILL && token! = BLOCK_SAME) {

SendTokenSA(CHANNEL_NON_ZERO, channel, sub, oct, bfp, &full, branch);

for(i=1; i < sub; i++)

SendTokenSA(token == NON_ZERO_STILL ? ZERO_STILL : BLOCK_SAME, channel, i, oct, bfp, &full, branch);

*empty = FULL;

SendTokenSA(token, channel, sub, oct, bfp, empty, branch);

}

break;

case OCTAVE_EMPTY:

if (token! = ZERO_STILL && token! = BLOCK_SAME) {

SendTokenSA(OCT_NON_ZERO, channel, sub, oct, bfp, &full, branch);

for(i=0; i < branch; i++)

SendTokenSA(token == NON_ZERO_STILL ? ZERO_STILL : BLOCK_SAME, channel, sub

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```

    ,oct,bfp,&full,branch);
        *empty = FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case LPF_EMPTY:
    if (token != LPF_ZERO) {

SendTokenSA(LPF_LOC_NON_ZERO,channel,sub,oct,bfp,&full,branch);
        for(i=0;i < channel;i++)
SendTokenSA(LPF_ZERO,i,sub,oct,bfp,&full,branch);
        *empty = FULL;
        SendTokenSA(token,channel,sub,oct,bfp,empty,branch);
    }
    break;
case FULL:
    Dprintf("%s\n",token_name[token]);
    bwrite(&token_codes[token],token_bits[token],bfp);
    break;
}
}

```

```

/*  Function Name:    ReadBlockSA
*
*  Description:    Read block from video
*
*  Arguments:    new, old, addr - new and old blocks and addresses
*
*                x, y, oct, sub, channel - co-ordinates of block
*
*                src, dst - frame data
*
*  Returns:    block values
*/

```

```
void  ReadBlockSA(new,old,addr,x,y,oct,sub,channel,src,dst)
```

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```

Block new, old, addr;
int    x, y, oct, sub, channel;
short  *src[3], *dst[3];

{
    int    X, Y;

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        addr[X][Y]=AccessSA((x<<1)+X,(y<<1)+Y,oct,sub,channel);
        new[X][Y]=(int)src[channel][addr[X][Y]];
        old[X][Y]=(int)dst[channel][addr[X][Y]];
    }
}

```

```

/*  Function Name:    CalcNormalsSA
 *
 *  Description:    Calculates HVS weighted normals
 *
 *  Arguments:    oct, sub, channel - co-ordinates
 *
 *                  norms - pre-initialised normals
 *
 *  Returns:    weighted normals
 */

```

```

void  CalcNormalsSA(oct,sub,channel,norms,quant_const)

```

```

int    oct, sub, channel;
double    norms[3], quant_const;

{
    int    norm, base_oct=oct+(channel!=0?1:0)+(sub==0?1:0);

    for(norm=0;norm<3;norm++) {
        if (norm!=0) norms[norm] *= quant_const;
        norms[norm] *= base_factors[base_oct]*(sub==3?diag_factor:1.0);
    }
}

```

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```

        if (channel!=0) norms[norm] *= chrome_factor;
        norms[norm] *=(double)(1<<SA_PRECISION);
    }
}

/*  Function Name:      MakeDecisions2SA
 *  Description:  Decide on new compression mode from block values
 *  Arguments:   old, new, pro - block values
 *
 *              zero - zero flag for new block
 *              norms - HVS normals
 *              mode - current compression mode
 *              decide - comparison algorithm
 *  Returns:     new compression mode
 */

int  MakeDecisions2SA(old,new,pro,lev,zero,norms,mode)

Block  new, old, pro, lev;
Boolean  zero;
double  norms[3];
int  mode;

{
    Block  zero_block={{0,0},{0,0}};
    int  new_mode=mode==STILL || BlockZeroSA(old)?STILL:SEND,
        np=DecideSA(new,pro), no=DecideSA(new,old);

    if (new_mode==STILL) new_mode=np>=no || zero ||
BlockZeroSA(lev)?STOP:STILL;
    else new_mode=zero && np<no?VOID:np>=no ||
DecisionSA(new,old,norms[2]) || BlockZeroSA(lev)?STOP:SEND;
    return(new_mode);
}

```

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}

```

/*  Function Name:      UpdateCoeffsSA
 *
 *  Description:  Encode proposed values and write data
 *
 *  Arguments:   pro, lev, addr - proposed block, levels and addresses
 *
 *               channel, oct - co-ordinates
 *
 *               dst - destination data
 *
 *               bfp - binary file pointer
 *
 *  Returns:     alters dst[channel][addr[]]
 */

```

```

void  UpdateCoeffsSA(pro,lev,addr,channel,oct,dst,bfp)

```

```

Block  pro, lev, addr;

```

```

int    channel, oct;

```

```

short  *dst[3];

```

```

Bits   bfp;

```

```

{

```

```

    int    X, Y;

```

```

    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {

```

```

        int    bits=HuffmanSA(lev[X][Y]),

```

```

            level=abs(lev[X][Y]);

```

```

        unsigned char    *bytes=HuffCodeSA(lev[X][Y]);

```

```

        dst[channel][addr[X][Y]]=(short)pro[X][Y];

```

```

        bwrite(bytes,bits,bfp);

```

```

        XtFree(bytes);

```

```

    }

```

```

}

```

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```

/*  Function Name:    SendTreeSA
*   Description:    Encode tree blocks
*   Arguments:    prev_mode - compression mode
*                  x, y, oct, sub, channel - co-ordinates
*                  empty - token mode
*                  branch - tree branch number
*   Returns:    active block indicator
*/

```

Boolean

SendTreeSA(prev_mode,x,y,oct,sub,channel,src,dst,empty,branch,quant_const,bfp)

int prev_mode, x, y, oct, sub, channel, *empty, branch;

short *src[3], *dst[3];

double quant_const;

Bits bfp;

{

Block addr, old, new, pro, lev;

int new_mode, X, Y;

double norms[3]={quant_const,thresh_const,cmp_const}; /* quant. thresh.

compare */

Boolean active=False;

ReadBlockSA(new,old,addr,x,y,oct,sub,channel,src,dst);

if (prev_mode!=VOID) {

Boolean zero;

CalcNormalsSA(oct,sub,channel,norms,quant_const);

zero=ProposedSA(pro,lev,old,new,norms);

new_mode=MakeDecisions2SA(old,new,pro,lev,zero,norms,prev_mode);

switch(new_mode) {

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```

case STOP:
    SendTokenSA(prev_mode == STILL ||
BlockZeroSA(old)?ZERO_STILL:BLOCK_SAME.channel,sub,oct,bfp,empty,branch);
    break;
case STILL:
case SEND:
    active = True;
    SendTokenSA(prev_mode == STILL ||
BlockZero(old)?NON_ZERO_STILL:BLOCK_CHANGE.channel,sub,oct,bfp,empty,branch);
    UpdateCoeffsSA(pro,lev,addr,channel,oct,dst,bfp);
    break;
case VOID:
    SendTokenSA(ZERO_VID,channel,sub,oct,bfp,empty,branch);
    ZeroCoeffsSA(dst[channel],addr);
    break;
    }
} else {
    if (BlockZeroSA(old)) new_mode = STOP;
    else {
        ZeroCoeffsSA(dst[channel],addr);
        new_mode = VOID;
    }
}
if (oct > 0 && new_mode != STOP) {
    int    mt = OCTAVE_EMPTY, full = FULL;

    Dprintf("x = %d, y = %d, oct = %d sub = %d mode
%d\n".x,y,oct,sub,new_mode);
    for(Y=0; Y<2; Y++) for(X=0; X<2; X++)

(void)SendTreeSA(new_mode.x*2+X,y*2+Y,oct-1,sub,channel,src,dst,&mt,X+2*Y,qua

```


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```

nt_const.bfp);
    if (mt == OCTAVE_EMPTY && new_mode != VOID)
SendTokenSA(OCT_ZERO, channel.sub.oct.bfp, &full, 0);
    }
    return(active);
}

```

```

/*  Function Name:    SendLPF_SA
 *  Description:    Encode LPF sub-band
 *  Arguments:    mode - compression mode
 *  Returns:    encodes data
 */

```

```

void  SendLPF_SA(mode, src, dst, bfp, quant_const)

```

```

int    mode;
short  *src[3], *dst[3];
Bits    bfp;
double    quant_const;

```

```

{
    Block new, old, pro, lev, addr;
    int    channel, channels=3, x, y, full=FULL,
          ocs_lum=3,

size[2]={SA_WIDTH>>ocs_lum+1,SA_HEIGHT>>ocs_lum+1};

    for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
        int    empty=LPF_EMPTY;

        for(channel=0;channel<channels;channel++) {
            int    ocs=channel!=0?2:3,

```

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```

        new_mode, X, Y, step, value, bits=0;
double    norms[3]={quant_const,thresh_const,cmp_const};

CalcNormalsSA(octs-1,0,channel,norms.quant_const);
step=norms[0] < 1.0?1:(int)norms[0];
for(bits=0, value=((1 < 8+SA_PRECISION)-1)/step;value!=0;bits++)
    value=value > > 1;
ReadBlockSA(new,old,addr,x,y,octs-1,0,channel,src,dst);

/* Proposed */
for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++)

pro[X][Y]=old[X][Y]+QuantizeSA(new[X][Y]-old[X][Y],step,&(lev[X][Y]));

/* MakeDecisions */
new_mode=mode==STILL?STILL:DecisionSA(new,old,norms[2]) ||
BlockZeroSA(lev)?STOP:SEND;

switch(new_mode) {
case SEND:
    SendTokenSA(LPF_NON_ZERO,channel,0,octs,bfp,&empty,0);
    UpdateCoeffsSA(pro,lev,addr,channel,octs,dst,bfp);
break;
case STILL:
    for(X=0;X<BLOCK;X++) for(Y=0;Y<BLOCK;Y++) {
        unsigned char *bytes=CodeIntSA(lev[X][Y],bits);

        dst[channel][addr[X][Y]]=(short)pro[X][Y];
        bwrite(bytes,bits,bfp);
        XtFree(bytes);
    }
break;

```

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```

        case STOP:
            SendTokenSA(LPF_ZERO,channel,0,octs,bfp,&empty,0);
            break;
        }
    }

    if (mode!=STILL && empty==LPF_EMPTY)
        SendTokenSA(LPF_LOC_ZERO,channel,0,octs_lum,bfp,&full,0);
    }
}

```

```

/*  Function Name:    CompressFrameSA
 *
 *  Description:      Compress a Frame
 *
 *  Arguments:        mode - compression mode STILL or SEND
 *
 *                    src, dst - source and destination data
 *
 *                    bfp - binary file pointer for result
 *
 *                    quant_const - quantization parameter
 */

```

```
void CompressFrameSA(mode,src,dst,bfp,quant_const)
```

```
int mode;
```

```
short *src[3], *dst[3];
```

```
Bits bfp;
```

```
double quant_const;
```

```
{
```

```
    int sub, channel, x, y, i;
```

```
        octs_lum=3;
```

```
size[2]={SA_WIDTH>>1+octs_lum.SA_HEIGHT>>1+octs_lum};
```

```
for(channel=0;channel<3;channel++) {
```

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```

    int
frame_size[2]={SA_WIDTH>>(channel==0?0:1),SA_HEIGHT>>(channel==0?0:1
)}}.

    frame_area=frame_size[0]*frame_size[1];

    for(i=0;i<frame_area;i++)
src[channel][i]=src[channel][i]<<SA_PRECISION;
    Convolve(src[channel],False,frame_size,0,channel==0?3:2);
}

bwrite((char *)&quant_const,sizeof(double)*8,bfp);
SendLPF_SA(mode,src,dst,bfp,quant_const);
for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {
    int    empty=EMPTY, full=FULL;

    for(channel=0;channel<3;channel++) {
        int    octs=channel!=0?2:3;

        for(sub=1;sub<4;sub++)
(void)SendTreeSA(mode,x,y,octs-1,sub,channel,src,dst,&empty,0,quant_const,bfp);
        switch(empty) {
            case FULL:
                empty=CHANNEL_EMPTY;
                break;
            case CHANNEL_EMPTY:
SendTokenSA(CHANNEL_ZERO,channel,sub,octs-1,bfp,&full,0);
                break;
        }
    }
}

    if (empty==EMPTY)
SendTokenSA(LOCAL_ZERO,channel,sub,octs_lum-1,bfp,&full,0);
}
}

```

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source/KlicsTestSA.c

#include "xwave.h"

#include "KlicsSA.h"

extern void CompressFrameSA();

typedef struct {

Video src;

char bin_name[STRLEN];

Boolean stillvid;

double quant_const;

} KlicsCtrlRec, *KlicsCtrl;

/* Function Name: KlicsCtrlSA

* Description: Test harness for KlicsSA in xwave

* Arguments: w - Xaw widget

* closure - compression control record

* call_data - NULL

* Returns: send data to binary file

*/

void KlicsCtrlSA(w, closure, call_data)

Widget w;

caddr_t closure, call_data;

{

KlicsCtrl ctrl=(KlicsCtrl)closure;

int sizeY=SA_WIDTH*SA_HEIGHT,

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```

        sizeUV = SA_WIDTH*SA_HEIGHT/4, i, z;

short  *dst[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
}, *src[3]={
    (short *)MALLOC(sizeof(short)*sizeY),
    (short *)MALLOC(sizeof(short)*sizeUV),
    (short *)MALLOC(sizeof(short)*sizeUV),
};

char   file_name[STRLEN];
Bits   bfp;
Boolean   true = True, false = False;

for(i=0;i<sizeY;i++) dst[0][i]=0;
for(i=0;i<sizeUV;i++) { dst[1][i]=0; dst[2][i]=0; }

sprintf(file_name,"%s%s/%s%s\0",global->home,KLICSA_DIR,ctrl->bin_name,KLI
CS_SA_EXT);
bfp=bopen(file_name,"w");
bwrite(&ctrl->stillvid,1,bfp);
bwrite(&ctrl->src->size[2],sizeof(int)*8,bfp);
for(z=0;z<ctrl->src->size[2];z++) {
    GetFrame(ctrl->src,z);
    for(i=0;i<sizeY;i++) src[0][i]=ctrl->src->data[0][z][i];
    for(i=0;i<sizeUV;i++) {
        src[1][i]=ctrl->src->data[1][z][i];
        src[2][i]=ctrl->src->data[2][z][i];
    }
    CompressFrameSA(z==0 ||

```

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```
ctrl->stillvid?STILL:SEND.src.dst.bfp,ctrl->quant_const);
```

```
    FreeFrame(ctrl->src,z);
```

```
}
```

```
bflush(bfp);
```

```
bclose(bfp);
```

```
XtFree(dst[0]);
```

```
XtFree(dst[1]);
```

```
XtFree(dst[2]);
```

```
XtFree(src[0]);
```

```
XtFree(src[1]);
```

```
XtFree(src[2]);
```

```
}
```

```
KlicsCtrl    InitKlicsCtrl(name)
```

```
String name;
```

```
{
```

```
    KlicsCtrl    ctrl=(KlicsCtrl)MALLOC(sizeof(KlicsCtrlRec));
```

```
    ctrl->stillvid = True;
```

```
    ctrl->quant_const=8.0;
```

```
    strcpy(ctrl->bin_name.name);
```

```
    return(ctrl);
```

```
}
```

```
#define    KLICS_SA_ICONS 8
```

```
#define KLICS_SA_VID_ICONS 2
```

```
void    KlicsSA(w,closure.call_data)
```

```
Widget    w;
```

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caddr_t closure, call_data;

{

Video video=(Video)closure;

KlicsCtrl ctrl=InitKlicsCtrl(video->name);

FloatInput flt_inputs=(FloatInput)MALLOC(sizeof(FloatInputRec));

Message msg_bin=NewMessage(ctrl->bin_name,NAME_LEN);

XtCallbackRec destroy_call[]={

{Free,(caddr_t)ctrl},

{Free,(caddr_t)flt_inputs},

{CloseMessage,(caddr_t)msg_bin},

{NULL,NULL},

};

Widget parent=FindWidget("frm_compress",XtParent(w)),

shell=ShellWidget("klicsSA",parent,SW_below,NULL,destroy_call),

form=FormWidget("klicsSA_form",shell),

widgets[KLICS_SA_ICONS],

vid_widgets[KLICS_SA_VID_ICONS];

FormItem items[]={

{"klicsSA_cancel","cancel",0,0,FW_icon,NULL},

{"klicsSA_confirm","confirm",1,0,FW_icon,NULL},

{"klicsSA_title","Run Klics SA",2,0,FW_label,NULL},

{"klicsSA_bin_lab","KLICS File:",0,3,FW_label,NULL},

{"klicsSA_bin_name",NULL,4,3,FW_text,(String)msg_bin},

{"klicsSA_qn_float",NULL,0,5,FW_float,(String)&flt_inputs[0]},

{"klicsSA_qn_scroll",NULL,6,5,FW_scroll,(String)&flt_inputs[0]},

{"klicsSA_vid_form",NULL,0,7,FW_form,NULL},

}, vid_items[]={

{"klicsSA_ic_lab","Image Comp:",0,0,FW_label,NULL},

{"klicsSA_ic",NULL,1,0,FW_yn,(String)&ctrl->stillvid},

};

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```

XtCallbackRec    callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {KlicsCtrlSA,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {FloatIncDec,(caddr_t)&flt_inputs[0]}, {NULL,NULL},
}, vid_call[]={
    {ChangeYN,(caddr_t)&ctrl->stillvid}, {NULL,NULL},
};

```

```
ctrl->src=video;
```

```
msg_bin->rows=1; msg_bin->cols=NAME_LEN;
```

```
flt_inputs[0].format="Quant: %4.1f";
```

```
flt_inputs[0].max=10;
```

```
flt_inputs[0].min=0;
```

```
flt_inputs[0].value= &ctrl->quant_const;
```

```
FillForm(form,KLICS_SA_ICONS-(video->size[2]>1?0:1),items.widgets,callbacks);
```

```
if (video->size[2]>1)
```

```
FillForm(widgets[7],KLICS_SA_VID_ICONS,vid_items,vid_widgets,vid_call);
```

```
XtPopup(shell,XtGrabExclusive);
```

```
}
```

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source/Malloc.c

```
/*  
    Memory allocation routine  
*/  
  
#include    <stdio.h>  
  
char  *MALLOC(size)  
  
int    size;  
  
{  
    char *ptr=(char *)calloc(1,size);  
  
    if (ptr == NULL) Eprintf("Unable to allocate %d bytes of memory\n",size);  
    return(ptr);  
}
```

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source/Menu.c

```
/*
 * Pull-Right Menu functions
 */

#include <stdio.h>
#include <X11/IntrinsicP.h>
#include <X11/StringDefs.h>

#include <X11/Xaw/XawInit.h>
#include <X11/Xaw/SimpleMenP.h>
#include <X11/Xaw/CommandP.h>

static void prPopupMenu();
static void NotifyImage();
static void PrLeave();

void InitActions(app_con)

XtAppContext app_con:

{
    static XtActionsRec actions[] = {
        {"prPopupMenu", prPopupMenu},
        {"notifyImage", NotifyImage},
        {"prLeave", PrLeave},
    };

    XtAppAddActions(app_con.actions, XtNumber(actions));
```

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```
}  
  
static void prPopupMenu(w.event.params.num_params)
```

```
Widget w;
```

```
XEvent * event;
```

```
String * params;
```

```
Cardinal * num_params;
```

```
{
```

```
Widget menu, temp;
```

```
Arg arglist[2];
```

```
Cardinal num_args;
```

```
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
```

```
Position button_x, button_y;
```

```
if (*num_params != 1) {
```

```
    char error_buf[BUFSIZ];
```

```
    sprintf(error_buf, "prPopupMenu: %s.", "Illegal number of translation  
arguments");
```

```
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
```

```
    return;
```

```
}
```

```
temp = w;
```

```
while(temp != NULL) {
```

```
    menu = XtNameToWidget(temp, params[0]);
```

```
    if (menu == NULL)
```

```
        temp = XtParent(temp);
```

```
    else
```

```
        break;
```

```
}
```

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```
if (menu == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "prPopupMenu: %s %s.",
        "Could not find menu widget named", params(0));
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

if (!XtIsRealized(menu))
    XtRealizeWidget(menu);

menu_width = menu->core.width + 2 * menu->core.border_width;
button_width = w->core.width + 2 * w->core.border_width;
button_height = w->core.height + 2 * w->core.border_width;

menu_height = menu->core.height + 2 * menu->core.border_width;

XtTranslateCoords(w, 0, 0, &button_x, &button_y);
menu_x = button_x;
menu_y = button_y + button_height;

if (menu_x < 0)
    menu_x = 0;
else {
    int scr_width = WidthOfScreen(XtScreen(menu));
    if (menu_x + menu_width > scr_width)
        menu_x = scr_width - menu_width;
}

if (menu_y < 0)
    menu_y = 0;
else {
    int scr_height = HeightOfScreen(XtScreen(menu));
```

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```

    if (menu_y + menu_height > scr_height)
        menu_y = scr_height - menu_height;
}

num_args = 0;
XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;
XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;
XtSetValues(menu, arglist, num_args);

XtPopupSpringLoaded(menu);
}
/*
static void
prRealize(w, mask, attrs)
Widget w;
Mask *mask;
XSetWindowAttributes *attrs;
{
    (*superclass->core_class.realize) (w, mask, attrs);
}
/* We have a window now. Register a grab. */
/*
XGrabButton( XtDisplay(w), AnyButton, AnyModifier, XtWindow(w),
              TRUE, ButtonPressMask|ButtonReleaseMask,
              GrabModeAsync, GrabModeAsync, None, None );
}
*/

static void NotifyImage(w,event,params,num_params)

Widget      w;
XEvent      *event;

```

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`String *params;``Cardinal *num_params;``{``CommandWidget cbw=(CommandWidget)w;``if (cbw->command.set) XtCallCallbackList(w,cbw->command.callbacks,event);``}``static void PrLeave(w,event,params,num_params)``Widget w;``XEvent *event;``String *params;``Cardinal *num_params;``{``SimpleMenuWidget smw=(SimpleMenuWidget)w;``Dprintf("PrLeave\n");``}`

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source/Message.c

```
/*
 *   Message I/O Utility Routines
 */

#include    "../include/xwave.h"
#include    <varargs.h>

#define     MESS_ICONS      3

void  TextSize(msg)

Message    msg;

{
    int     i=-1, max_len=0;
    char    *text=msg->info.ptr;

    msg->rows=0;
    msg->cols=0;
    do {
        i++;
        if (text[i]=='\n' || text[i]=='\0') {
            if (msg->cols>max_len) max_len=msg->cols;
            msg->cols=0;
            msg->rows++;
        } else msg->cols++;
    } while (text[i]!='\0');
    if (i>0) if (text[i-1]=='\n') msg->rows--;
```


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```

    msg->cols=max_len;
}

Message    NewMessage(text,size)

char    *text;
int     size;

{
    Message    msg=(Message)MALLOC(sizeof(MessageRec));

    msg->shell=NULL;
    msg->widget=NULL;
    msg->info.firstPos=0;
    if (!(msg->own_text=text==NULL)) msg->info.ptr=text;
    else {
        msg->info.ptr=(char *)MALLOC(size+1);
        msg->info.ptr[0]='\0';
    }
    msg->info.format=FMT8BIT;
    msg->info.length=0;
    msg->rows=0;
    msg->cols=0;
    msg->size=size;
    msg->edit=XawtextEdit;
    return(msg);
}

```

```

void    CloseMessage(w,closure,call_data)

```

```

Widget    w;
caddr_t    closure, call_data;

```

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```

{
    Message    msg=(Message)closure;

    Destroy(w,(caddr_t)msg->shell.NULL);
    if (msg->own_text) XtFree(msg->info.ptr);
    XtFree(msg);
}

void  MessageWindow(parent,msg,title,close,call)

Widget      parent;
Message      msg;
char  *title;
Boolean      close;
XtCallbackRec  call[];

{
    Widget      form, widgets[MESS_ICONS]={NULL,NULL,NULL};
    FormItem     items[]={
        {"msg_cancel","cancel",0,0,FW_icon,NULL},
        {"msg_label",title,1,0,FW_label,NULL},
        {"msg_msg",NULL,0,2,FW_text,(String)msg},
    };

    msg->edit=XawtextRead;

    msg->shell=ShellWidget("msg",parent,parent==global->toplevel?SW_top:SW_below,
        NULL.NULL);
    form=FormWidget("msg_form",msg->shell);

    FillForm(form.MESS_ICONS-(close?0:1),&items[close?0:1],&widgets[close?0:1],call);
    XtPopup(msg->shell,XtGrabNone);
}

```

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```

    Mflush(msg);
}

void Mflush(msg)

Message    msg;

{
    if (global->batch == NULL && msg->widget != NULL) {
        Display    *dpy = XtDisplay(global->toplevel);
        int    i, lines = 0;
        Arg    args[1];

        for(i = msg->info.length-1; lines < msg->rows && i >= 0; i--)
            if (msg->info.ptr[i] == '\n' && i != msg->info.length-1) lines++;
        i++;
        if (msg->info.ptr[i] == '\n') i++;
        strcpy(msg->info.ptr, &msg->info.ptr[i]);
        msg->info.length = i;
        XtSetArg(args[0], XtNstring, msg->info.ptr);
        XSynchronize(dpy, True);
        XtSetValues(msg->widget, args, ONE);
        XSynchronize(dpy, False);
    }
}

void mprintf(msg, ap)

Message    msg;
va_list    ap;

{

```

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```
char *format;

format=va_arg(ap,char *);
if (global->batch!=NULL) vprintf(format,ap);
else {
    char text[STRLEN];
    int i;

    vsprintf(text,format,ap);
    i=strlen(text)+msg->info.length-msg->size;
    if (i>0) {
        strcpy(msg->info.ptr,&msg->info.ptr[i]);
        msg->info.length-=i;
    }
    strcat(msg->info.ptr,text);
    msg->info.length+=strlen(text);
}
}
```

```
void Dprintf(va_list
```

```
va_dcl
```

```
{
```

```
    va_list ap;
```

```
    if (global->debug) {
```

```
        char *format;
```

```
        va_start(ap);
```

```
        format=va_arg(ap,char *);
```

```
        vprintf(format,ap);
```

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```
        va_end(ap);
    }
}

void Mprintf(va_alist)

va_dcl

{
    va_list      ap;
    Message      msg;

    va_start(ap);
    msg = va_arg(ap, Message);
    mprintf(msg, ap);
    va_end(ap);
}

void Eprintf(va_alist)

va_dcl

{
    va_list      ap;
    Message      msg;
    int          rows, cols;

    va_start(ap);
    msg = NewMessage(NULL, STRLEN);
    mprintf(msg, ap);
    if (global->batch == NULL) {
        XtCallbackRec      callbacks[] = {
```

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```
{CloseMessage,(caddr_t)msg},  
{NULL,NULL},
```

```
};
```

```
TextSize(msg);
```

```
MessageWindow(global->toplevel,msg,"Xwave Error",True,callbacks);
```

```
}
```

```
va_end(ap);
```

```
}
```

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source/NameButton.c

```

/*
 *   Supply MenuButton widget id to PullRightMenu button resource
 */

```

```

#include      "../include/xwave.h"

```

```

void  NameButton(w, event, params, num_params)

```

```

Widget      w;

```

```

XEvent      *event;

```

```

String *params;

```

```

Cardinal      *num_params;

```

```

{

```

```

    MenuButtonWidget  mbw=(MenuButtonWidget) w;

```

```

    Widget      menu;

```

```

    Arg  args[1];

```

```

    String name;

```

```

    XtSetArg(args[0],XtNmenuName,&name);

```

```

    XtGetValues(w,args,ONE);

```

```

    Dprintf("NameButton: looking for PRM %s\n",name);

```

```

    menu=FindWidget(name,w);

```

```

    if (menu != NULL) {

```

```

        Dprintf("NameButton: setting Menu Button\n");

```

```

        XtSetArg(args[0],XtNbutton,w);

```

```

        XtSetValues(menu,args,ONE);

```

```

    }

```

```

}

```

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source/Palette.c

```

/*
 *   Palette re-mapping
 */

#include    "../include/xwave.h"

/*   Function Name:    ReMap
 *   Description:    Re-maps a pixel value to a new value via a mapping
 *   Arguments:    pixel - pixel value (0..max-1)
 *                  max - range of pixel values
 *                  map - palette to recode with
 *   Returns:    remapped pixel value
 */

int    ReMap(pixel,max,palette)

int    pixel, max;
Palette    palette;

{
    Map    map=palette->mappings;
    int    value=pixel;
    Boolean    inrange=False;

    while(map!=NULL && !inrange) {
        if (pixel >= map->start && pixel <= map->finish) {
            inrange=True;
            value=map->m*pixel+map->c;

```


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```

    }
    map=map->next;
}
return(value<0?0:value>=max?max-1:value);
}

```

```

/*  Function Name:    FindPalette
 *  Description:    Find a palette from a list given the index
 *  Arguments:    palette - the palette list
 *                index - the index number
 *  Returns:    the palette corresponding to the index
 */

```

```

Palette    FindPalette(palette,index)

```

```

Palette    palette;
int        index;

{
    while(index>0 && palette->next!=NULL) {
        index--;
        palette=palette->next;
    }
    return(palette);
}

```

```

/*  Function Name:    ReOrderPalettes
 *  Description:    Reverse the order of the palette list
 *  Arguments:    start, finish - the start and finish of the re-ordered list
 *  Returns:    the palette list in the reverse order
 */

```

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Palette ReOrderPalettes(start,finish)

Palette start, finish;

```
{  
    Palette list=finish->next;  
  
    if (list!=NULL) {  
        finish->next=list->next;  
        list->next=start;  
        start=ReOrderPalettes(list,finish);  
    }  
    return(start);  
}
```

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source/Parse.c

```
/*
 *   Parser for xwave input files: .elo
 */

#include    "../include/xwave.h"
#include    "../include/Gram.h"

void  Parse(path,file,ext)

String path, file, ext;

{
    char  file_name[STRLEN];

    sprintf(file_name,"%s%s/%s%s\0",global->home,path,file,ext);
    Dprintf("Parse: parsing file %s\n",file_name);
    if (NULL == (global->parse_fp=fopen(file_name,"r")))
        Eprintf("Parse: failed to open input file %s\n",file_name);
    else {
        sprintf(file_name,"%s%s\0",file,ext);
        global->parse_file=file_name;
        global->parse_token=ext;
        yyparse();
        fclose(global->parse_fp);
        Dprintf("Parse: finished with %s\n",file_name);
    }
}
```

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```
void ParseCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data:
```

```
{
    Parse(".",((XawListReturnStruct *)call_data)->string,(String)closure);
}
```

```
int ParseInput(fp)
```

```
FILE *fp;
```

```
{
    int num;

    if (global->parse_token!=NULL)
        if (global->parse_token[0]=='\0') {
            num=(int)'\n';
            global->parse_token=NULL;
        } else {
            num=(int)global->parse_token[0];
            global->parse_token++;
        }
    else if (EOF==(num=getc(global->parse_fp))) num=NULL;
    return(num);
}
```

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source/Pop2.c

```
/*  
    Global callbacks for popping popups and allsorted utilities  
*/
```

```
#include    "../include/xwave.h"
```

```
void Destroy(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{  
    Widget      widget=(Widget)closure;  
  
    if (widget!=NULL) XtDestroyWidget(widget);  
}
```

```
void Quit(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{  
    XtDestroyApplicationContext(global->app_con);  
    exit();  
}
```

```
void Free(w,closure,call_data)
```

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```
Widget      w;
caddr_t     closure, call_data;
```

```
{
    if (closure != NULL) XtFree(closure);
}
```

```
Widget      FindWidget(name, current)
```

```
String name;
```

```
Widget      current;
```

```
{
    Widget    target = NULL;

    while(current != NULL) {
        target = XtNameToWidget(current, name);
        if (target == NULL) current = XtParent(current);
        else break;
    }

    if (target == NULL) {
        Eprintf("Cant find widget: %s\n", name);
        target = global->toplevel;
    }

    return(target);
}
```

```
#define      NA_ICONS 2
```

```
void NA(w, closure, call_data)
```

```
Widget      w;
```

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```
caddr_t      closure, call_data;
```

```
{
    Widget
    shell=ShellWidget("na_shell",(Widget)closure,SW_below,NULL,NULL),
        form=FormatWidget("na_form",shell), widgets[NA_ICONS];
    FormItem  items[]={
        {"na_confirm","confirm",0,0,FW_icon,NULL},
        {"na_label","This function is not available",0,1,FW_label,NULL},
    };
    XtCallbackRec  callbacks[]={
        {Destroy,(caddr_t)shell}, {NULL,NULL},
    };

    FillForm(form,NA_ICONS,items,widgets,callbacks);
    XtPopup(shell,XtGrabExclusive);
}
```

```
void  SetSensitive(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
    XtSetSensitive((Widget)closure,True);
}
```

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source/Process.c

```
/*
 *   Call sub-processes
 */

#include    "../include/xwave.h"
#include    <signal.h>
#include    <sys/wait.h>
#include    <sys/time.h>
#include    <sys/resource.h>

/*
 *   Function Name:      Fork
 *   Description:        Executes a file in a process and waits for termination
 *   Arguments:          argv - standard argv argument description
 *   Returns:            dead process id
 */

int  Fork(argv)

char *argv[];

{
    int  pid;
    union wait  statusp;
    struct rusage  rusage;

    if (0 == (pid = fork())) {
        execvp(argv[0], argv);
        exit();
    }
}
```


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```

    } else if (pid > 0) wait4(pid, &statusp, 0, &rusage);
    return(pid);
}

```

```

/*  Function Name:      zropen
 *
 *  Description:   Open a file (or .Z file) for reading
 *
 *  Arguments:    file_name - name of the file to be read
 *
 *                pid - pointer to process id
 *
 *  Returns:      file pointer
 */

```

```

FILE *zropen(file_name, pid)

```

```

char *file_name;

```

```

int *pid;

```

```

{

```

```

    char z_name[STRLEN];

```

```

    String zcat[] = {"zcat", z_name, NULL};

```

```

    FILE *fp;

```

```

    if (NULL == (fp = fopen(file_name, "r"))) {

```

```

        static int up[2];

```

```

        sprintf(z_name, "%s.Z", file_name);

```

```

        pipe(up);

```

```

        if (0 != (*pid = fork())) {

```

```

            Dprintf("Parent process started\n");

```

```

            close(up[1]);

```

```

            fp = fdopen(up[0], "r");

```

```

        } else {

```

```

            Dprintf("Running zcat on %s\n", zcat[1]);

```

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```

        close(up[0]);
        dup2( up[1], 1 );
        close( up[1] );
        execvp(zcat[0],zcat);
    }
}
return(fp);
}

```

```

/*  Function Name:    zseek
 *   Description:    Fast-forward thru file (fseek will not work on pipes)
 *   Arguments:      fp - file pointer
 *                   bytes - bytes to skip
 */

```

```
void  zseek(fp,bytes)
```

```
FILE  *fp;
```

```
int   bytes;
```

```

{
    char  scratch[1000];
    int   i;

    while(bytes > 0) {
        int  amount = bytes > 1000 ? 1000 : bytes;

        fread(scratch,sizeof(char),amount,fp);
        bytes -= amount;
    }
}

```

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```
void zclose(fp,pid)
```

```
FILE *fp;
```

```
int pid;
```

```
{
```

```
    union wait statusp;
```

```
    struct rusage rusage;
```

```
    fclose(fp);
```

```
    if (pid!=0) wait4(pid,&statusp,0,&rusage);
```

```
}
```

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source/PullRightMenu.c

#if (!defined(lint) && !defined(SABER))

static char Xrcsid[] = "\$XConsortium: PullRightMenu.c,v 1.32 89/12/11 15:01:50 kit
Exp \$";

#endif

/*

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*/

/*

* PullRightMenu.c - Source code file for PullRightMenu widget.

*

*/

#include <stdio.h>

#include <X11/IntrinsicP.h>

#include <X11/StringDefs.h>

#include <X11/Xaw/XawInit.h>

#include <X11/Xaw/SimpleMenP.h>

#include "PullRightMenuP.h"

#include <X11/Xaw/SmeBSB.h>

#include "SmeBSBpr.h"

#include <X11/Xaw/Cardinals.h>

#include <X11/Xmu/Initer.h>

#include <X11/Xmu/CharSet.h>

#define streq(a, b) (strcmp((a), (b)) == 0)

#define offset(field) XtOffset(PullRightMenuWidget, simple_menu.field)

static XtResource resources[] = {

/*

* Label Resources.

*/

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```
{XtNlabel, XtCLabel, XtRString, sizeof(String),
  offset(label_string), XtRString, NULL},
{XtNlabelClass, XtCLabelClass, XtRPointer, sizeof(WidgetClass),
  offset(label_class), XtRImmediate, (caddr_t) NULL},
```

/*

* Layout Resources.

*/

```
{XtNrowHeight, XtCRowHeight, XtRDimension, sizeof(Dimension),
  offset(row_height), XtRImmediate, (caddr_t) 0},
{XtNtopMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(top_margin), XtRImmediate, (caddr_t) 0},
{XtNbottomMargin, XtCVerticalMargins, XtRDimension, sizeof(Dimension),
  offset(bottom_margin), XtRImmediate, (caddr_t) 0},
```

/*

* Misc. Resources

*/

```
{ XtNallowShellResize, XtCAllowShellResize, XtRBoolean, sizeof(Boolean),
  XtOffset(SimpleMenuWidget, shell.allow_shell_resize),
  XtRImmediate, (XtPointer) TRUE },
{XtNcursor, XtCCursor, XtRCursor, sizeof(Cursor),
  offset(cursor), XtRImmediate, (caddr_t) None},
{XtNmenuOnScreen, XtCMenuOnScreen, XtRBoolean, sizeof(Boolean),
  offset(menu_on_screen), XtRImmediate, (caddr_t) TRUE},
{XtNpopupOnEntry, XtCPopupOnEntry, XtRWidget, sizeof(Widget),
  offset(popup_entry), XtRWidget, NULL},
{XtNbackingStore, XtCBackingStore, XtRBackingStore, sizeof(int),
  offset(backing_store),
  XtRImmediate, (caddr_t) (Always + WhenMapped + NotUseful)},
```

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```

    {XtNbutton, XtCWidget, XtRWidget, sizeof(Widget),
      offset(button), XtRWidget, (XtPointer)NULL},
};
#undef offset

```

```

static char defaultTranslations[] =

```

```

    "<EnterWindow>: highlight() \n\
    <LeaveWindow>: pull() \n\
    <BtnMotion>: highlight() \n\
    <BtnUp>: execute()";

```

```

/*

```

```

    * Semi Public function definitions.

```

```

*/

```

```

static void Redisplay(), Realize(), Resize(), ChangeManaged();
static void Initialize(), ClassInitialize(), ClassPartInitialize();
static Boolean SetValues(), SetValuesHook();
static XtGeometryResult GeometryManager();

```

```

/*

```

```

    * Action Routine Definitions

```

```

*/

```

```

static void Highlight(), Unhighlight(), Pull(), Execute(), Notify(), PositionMenuAction();

```

```

/*

```

```

    * Private Function Definitions.

```

```

*/

```

```

static void MakeSetValuesRequest(), CreateLabel(), Layout();
static void AddPositionAction(), PositionMenu(), ChangeCursorOnGrab();

```

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```
static Dimension GetMenuWidth(), GetMenuHeight();
```

```
static Widget FindMenu();
```

```
static SmeObject GetEventEntry();
```

```
static XtActionsRec actionsList[] =
```

```
{
    {"pull",          Pull},
    {"execute",       Execute},
    {"notify",        Notify},
    {"highlight",     Highlight},
    {"unhighlight",   Unhighlight},
};
```

```
CompositeClassExtensionRec pr_extension_rec = {
```

```
    /* next_extension */ NULL,
    /* record_type */     NULLQUARK,
    /* version */         XtCompositeExtensionVersion,
    /* record_size */     sizeof(CompositeClassExtensionRec),
    /* accepts_objects */ TRUE,
};
```

```
#define superclass (&overrideShellClassRec)
```

```
PullRightMenuClassRec pullRightMenuClassRec = {
```

```
{
    /* superclass */ (WidgetClass) superclass,
    /* class_name */  "PullRightMenu",
    /* size */        sizeof(PullRightMenuRec),
    /* class_initialize */ ClassInitialize,
    /* class_part_initialize */ ClassPartInitialize,
    /* Class init'ed */  FALSE,
    /* initialize */     Initialize.
};
```


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```

/* initialize_hook */ NULL.
/* realize */ Realize.
/* actions */ actionsList.
/* num_actions */ XtNumber(actionsList).
/* resources */ resources.
/* resource_count */ XtNumber(resources).
/* xrm_class */ NULLQUARK.
/* compress_motion */ TRUE.
/* compress_exposure */ TRUE.
/* compress_enterleave*/ TRUE.
/* visible_interest */ FALSE.
/* destroy */ NULL.
/* resize */ Resize.
/* expose */ Redisplay.
/* set_values */ SetValues.
/* set_values_hook */ SetValuesHook.
/* set_values_almost */ XtInheritSetValuesAlmost.
/* get_values_hook */ NULL.
/* accept_focus */ NULL.
/* intrinsics version */ XtVersion.
/* callback offsets */ NULL.
/* tm_table */ defaultTranslations.
/* query_geometry */ NULL.
/* display_accelerator*/ NULL.
/* extension */ NULL
},{
/* geometry_manager */ GeometryManager.
/* change_managed */ ChangeManaged.
/* insert_child */ XtInheritInsertChild.
/* delete_child */ XtInheritDeleteChild.
/* extension */ NULL
},{

```

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```

/* Shell extension      */ NULL
},{
/* Override extension */ NULL
},{
/* Simple Menu extension*/ NULL
}
};

```

```
WidgetClass pullRightMenuWidgetClass = (WidgetClass)&pullRightMenuClassRec;
```

```

/*****
 *
 * Semi-Public Functions.
 *
 *****/

```

```

/*      Function Name: ClassInitialize
 *      Description: Class Initialize routine, called only once.
 *      Arguments: none.
 *      Returns: none.
 */

```

```

static void
ClassInitialize()
{
    XawInitializeWidgetSet();
    XtAddConverter( XtRString, XtRBackingStore, XmuCvtStringToBackingStore,
                   NULL, 0 );
    XmuAddInitializer( AddPositionAction, NULL);
}

```

```

/*      Function Name: ClassInitialize

```

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```

*   Description: Class Part Initialize routine. called for every
*               subclass. Makes sure that the subclasses pick up
*               the extension record.
*   Arguments: wc - the widget class of the subclass.
*   Returns: none.
*/

```

```
static void
```

```
ClassPartInitialize(wc)
```

```
WidgetClass wc;
```

```
{
```

```
    SimpleMenuWidgetClass smwc = (SimpleMenuWidgetClass) wc;
```

```
/*
```

```
* Make sure that our subclass gets the extension rec too.
```

```
*/
```

```
    pr_extension_rec.next_extension = smwc->composite_class.extension;
```

```
    smwc->composite_class.extension = (caddr_t) &pr_extension_rec;
```

```
}
```

```
/*   Function Name: Initialize
```

```
*   Description: Initializes the simple menu widget
```

```
*   Arguments: request - the widget requested by the argument list.
```

```
*               new      - the new widget with both resource and non
*                           resource values.
```

```
*   Returns: none.
```

```
*/
```

```
/* ARGSUSED */
```

```
static void
```

```
Initialize(request, new)
```

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Widget request, new;

{

SimpleMenuWidget smw = (SimpleMenuWidget) new;

XmuCallInitializers(XtWidgetToApplicationContext(new));

if (smw->simple_menu.label_class == NULL)

smw->simple_menu.label_class = smeBSBObjectClass;

smw->simple_menu.label = NULL;

smw->simple_menu.entry_set = NULL;

smw->simple_menu.recursive_set_values = FALSE;

if (smw->simple_menu.label_string != NULL)

CreateLabel(new);

smw->simple_menu.menu_width = TRUE;

if (smw->core.width == 0) {

smw->simple_menu.menu_width = FALSE;

smw->core.width = GetMenuWidth(new, NULL);

}

smw->simple_menu.menu_height = TRUE;

if (smw->core.height == 0) {

smw->simple_menu.menu_height = FALSE;

smw->core.height = GetMenuHeight(new);

}

/*

* Add a popup_callback routine for changing the cursor.

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*/

```

XtAddCallback(new, XtNpopupCallback, ChangeCursorOnGrab, NULL);
}

```

```

/* Function Name: Redisplay

```

```

* Description: Redisplays the contents of the widget.

```

```

* Arguments: w - the simple menu widget.

```

```

*          event - the X event that caused this redisplay.

```

```

*          region - the region the needs to be repainted.

```

```

* Returns: none.

```

*/

```

/* ARGSUSED */

```

```

static void

```

```

Redisplay(w, event, region)

```

```

Widget w;

```

```

XEvent * event;

```

```

Region region;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

    SmeObject * entry;

```

```

    SmeObjectClass class;

```

```

    if (region == NULL)

```

```

        XClearWindow(XtDisplay(w), XtWindow(w));

```

```

    /*

```

```

    * Check and Paint each of the entries - including the label.

```

```

    */

```

```

    ForAllChildren(smw, entry) {

```

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```
if (!XtIsManaged ( (Widget) *entry)) continue;
```

```
if (region != NULL)
```

```
    switch(XRectInRegion(region, (int) (*entry)->rectangle.x,
```

```
            (int) (*entry)->rectangle.y,
```

```
            (unsigned int) (*entry)->rectangle.width,
```

```
            (unsigned int) (*entry)->rectangle.height)) {
```

```
    case RectangleIn:
```

```
    case RectanglePart:
```

```
        break;
```

```
    default:
```

```
        continue;
```

```
    }
```

```
class = (SmcObjectClass) (*entry)->object.widget_class;
```

```
if (class->rect_class.expose != NULL)
```

```
    (class->rect_class.expose)( (Widget) *entry, NULL, NULL);
```

```
}
```

```
}
```

```
/*  Function Name: Realize
```

```
*  Description: Realizes the widget.
```

```
*  Arguments: w - the simple menu widget.
```

```
*           mask - value mask for the window to create.
```

```
*           attrs - attributes for the window to create.
```

```
*  Returns: none
```

```
*/
```

```
static void
```

```
Realize(w, mask, attrs)
```

```
Widget w;
```

```
XtValueMask * mask;
```

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```

XSetWindowAttributes * attrs;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;

    attrs->cursor = smw->simple_menu.cursor;
    *mask |= CWCursor;
    if ((smw->simple_menu.backing_store == Always) ||
        (smw->simple_menu.backing_store == NotUseful) ||
        (smw->simple_menu.backing_store == WhenMapped) ) {
        *mask |= CWBackingStore;
        attrs->backing_store = smw->simple_menu.backing_store;
    }
    else
        *mask &= ~CWBackingStore;

    (*superclass->core_class.realize) (w, mask, attrs);
}

```

```

/*    Function Name: Resize
 *    Description: Handle the menu being resized bigger.
 *    Arguments: w - the simple menu widget.
 *    Returns: none.
 */

```

```

static void
Resize(w)
Widget w;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    if ( !XtIsRealized(w) ) return;

```

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```

ForAllChildren(smw, entry)    /* reset width of all entries. */
    if (XtIsManaged( (Widget) *entry))
        (*entry)->rectangle.width = smw->core.width;

Redisplay(w, (XEvent *) NULL, (Region) NULL);
}

/*  Function Name: SetValues
 *  Description: Relayout the menu when one of the resources is changed.
 *  Arguments: current - current state of the widget.
 *              request - what was requested.
 *              new - what the widget will become.
 *  Returns: none
 */

/* ARGSUSED */
static Boolean
SetValues(current, request, new)
Widget current, request, new;
{
    SimpleMenuWidget smw_old = (SimpleMenuWidget) current;
    SimpleMenuWidget smw_new = (SimpleMenuWidget) new;
    Boolean ret_val = FALSE, layout = FALSE;

    if (!XtIsRealized(current)) return(FALSE);

    if (!smw_new->simple_menu.recursive_set_values) {
        if (smw_new->core.width != smw_old->core.width) {
            smw_new->simple_menu.menu_width = (smw_new->core.width != 0);
            layout = TRUE;
        }
        if (smw_new->core.height != smw_old->core.height) {

```


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```

        smw_new->simple_menu.menu_height = (smw_new->core.height != 0);
        layout = TRUE;
    }
}

if (smw_old->simple_menu.cursor != smw_new->simple_menu.cursor)
    XDefineCursor(XtDisplay(new),
        XtWindow(new), smw_new->simple_menu.cursor);

if (smw_old->simple_menu.label_string != smw_new->simple_menu.label_string)
    if (smw_new->simple_menu.label_string == NULL)        /* Destroy. */
        XtDestroyWidget(smw_old->simple_menu.label);
    else if (smw_old->simple_menu.label_string == NULL)    /* Create. */
        CreateLabel(new);
    else {
        /* Change. */
        Arg args[1];

        XtSetArg(args[0], XtNlabel, smw_new->simple_menu.label_string);
        XtSetValues(smw_new->simple_menu.label, args, ONE);
    }

if (smw_old->simple_menu.label_class != smw_new->simple_menu.label_class)
    XtAppWarning(XtWidgetToApplicationContext(new),
        "No Dynamic class change of the SimpleMenu Label.");

if ((smw_old->simple_menu.top_margin != smw_new->simple_menu.top_margin)
||
    (smw_old->simple_menu.bottom_margin !=
    smw_new->simple_menu.bottom_margin) /* filler..... */ ) {
    layout = TRUE;
    ret_val = TRUE;
}

```

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```
if (layout)
```

```
    Layout(new, NULL, NULL);
```

```
return(ret_val);
```

```
}
```

```
/*  Function Name: SetValuesHook
```

```
 *  Description: To handle a special case, this is passed the
 *               actual arguments.
```

```
 *  Arguments: w - the menu widget.
```

```
 *               arglist - the argument list passed to XtSetValues.
```

```
 *               num_args - the number of args.
```

```
 *  Returns: none
```

```
*/
```

```
/*
```

```
 * If the user actually passed a width and height to the widget
```

```
 * then this MUST be used, rather than our newly calculated width and
```

```
 * height.
```

```
*/
```

```
static Boolean
```

```
SetValuesHook(w, arglist, num_args)
```

```
Widget w;
```

```
ArgList arglist;
```

```
Cardinal *num_args;
```

```
{
```

```
    register Cardinal i;
```

```
    Dimension width, height;
```

```
    width = w->core.width;
```

```
    height = w->core.height;
```

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```

for ( i = 0 ; i < *num_args ; i++ ) {
    if ( strcmp(arglist[i].name, XtNwidth) )
        width = (Dimension) arglist[i].value;
    if ( strcmp(arglist[i].name, XtNheight) )
        height = (Dimension) arglist[i].value;
}

if ((width != w->core.width) || (height != w->core.height))
    MakeSetValuesRequest(w, width, height);
return(FALSE);
}

```

```

/*****
 *
 * Geometry Management routines.
 *
 *****/

```

```

/*  Function Name: GeometryManager
 *
 *  Description: This is the SimpleMenu Widget's Geometry Manager.
 *
 *  Arguments: w - the Menu Entry making the request.
 *
 *             request - requested new geometry.
 *
 *             reply - the allowed geometry.
 *
 *  Returns: XtGeometry{Yes, No, Almost}.
 */

```

```

static XtGeometryResult
GeometryManager(w, request, reply)
Widget w;
XtWidgetGeometry * request, * reply;
{

```

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```
SimpleMenuWidget smw = (SimpleMenuWidget) XtParent(w);
```

```
SmeObject entry = (SmeObject) w;
```

```
XtGeometryMask mode = request->request_mode;
```

```
XtGeometryResult answer;
```

```
Dimension old_height, old_width;
```

```
if ( !(mode & CWWidth) && !(mode & CWHeight) )
```

```
    return(XtGeometryNo);
```

```
reply->width = request->width;
```

```
reply->height = request->height;
```

```
old_width = entry->rectangle.width;
```

```
old_height = entry->rectangle.height;
```

```
Layout(w, &(reply->width), &(reply->height) );
```

```
/*
```

```
* Since we are an override shell and have no parent there is no one to
```

```
* ask to see if this geom change is okay, so I am just going to assume
```

```
* we can do whatever we want. If you subclass be very careful with this
```

```
* assumption, it could bite you.
```

```
*
```

```
* Chris D. Peterson - Sept. 1989.
```

```
*/
```

```
if ( (reply->width == request->width) &&
```

```
    (reply->height == request->height) ) {
```

```
    if ( mode & XtCWQueryOnly ) { /* Actually perform the layout. */
```

```
        entry->rectangle.width = old_width;
```

```
        entry->rectangle.height = old_height;
```

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```

    }
    else {
        Layout(( Widget) smw, NULL, NULL);
    }
    answer = XtGeometryDone;
}
else {
    entry->rectangle.width = old_width;
    entry->rectangle.height = old_height;

    if ( ((reply->width == request->width) && !(mode & CWHeight)) ||
        ((reply->height == request->height) && !(mode & CWWidth)) ||
        ((reply->width == request->width) &&
         (reply->height == request->height)) )
        answer = XtGeometryNo;
    else {
        answer = XtGeometryAlmost;
        reply->request_mode = 0;
        if (reply->width != request->width)
            reply->request_mode |= CWWidth;
        if (reply->height != request->height)
            reply->request_mode |= CWHeight;
    }
}
return(answer);
}

```

```

/*  Function Name: ChangeManaged
*   Description: called whenever a new child is managed.
*   Arguments: w - the simple menu widget.
*   Returns: none.
*/

```

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static void

ChangeManaged(w)

Widget w;

{

Layout(w, NULL, NULL);

}

/*****

*

* Global Action Routines.

*

* These actions routines will be added to the application's

* global action list.

*

*****/

/* Function Name: PositionMenuAction

* Description: Positions the simple menu widget.

* Arguments: w - a widget (no the simple menu widget.)

* event - the event that caused this action.

* params, num_params - parameters passed to the routine.

* we expect the name of the menu here.

* Returns: none

*/

/* ARGSUSED */

static void

PositionMenuAction(w, event, params, num_params)

Widget w;

XEvent * event;

String * params;

Cardinal * num_params;

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```
{
Widget menu;
XPoint loc;

if (*num_params != 1) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s %s",
            "Xaw - SimpleMenuWidget: position menu action expects only one",
            "parameter which is the name of the menu.");
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

if ( (menu = FindMenu(w, params[0])) == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s '%s'",
            "Xaw - SimpleMenuWidget: could not find menu named: ", params[0]);
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

switch (event->type) {
case ButtonPress:
case ButtonRelease:
    loc.x = event->xbutton.x_root;
    loc.y = event->xbutton.y_root;
    PositionMenu(menu, &loc);
    break;
case EnterNotify:
case LeaveNotify:
    loc.x = event->xcrossing.x_root;
    loc.y = event->xcrossing.y_root;
```

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```

    PositionMenu(menu, &loc);
    break;
case MotionNotify:
    loc.x = event->xmotion.x_root;
    loc.y = event->xmotion.y_root;
    PositionMenu(menu, &loc);
    break;
default:
    PositionMenu(menu, NULL);
    break;
}
}

```

```

/*****

```

```

*

```

```

* Widget Action Routines.

```

```

*

```

```

*****/

```

```

/*  Function Name: Unhighlight
*  Description: Unhighlights current entry.
*  Arguments: w - the simple menu widget.
*              event - the event that caused this action.
*              params, num_params - ** NOT USED **
*  Returns: none
*/

```

```

/* ARGSUSED */

```

```

static void

```

```

Unhighlight(w, event, params, num_params)

```

```

Widget w:

```

```

XEvent * event:

```


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```

String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( entry == NULL) return;

    smw->simple_menu.entry_set = NULL;
    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.unhighlight) ( (Widget) entry);
}

```

```

/*  Function Name: Highlight
 *   Description: Highlights current entry.
 *   Arguments: w - the simple menu widget.
 *               event - the event that caused this action.
 *               params, num_params - ** NOT USED **
 *   Returns: none
 */

```

```

/* ARGSUSED */
static void
Highlight(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry;

```

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```

SmeObjectClass class;

if ( !XtIsSensitive(w) ) return;

entry = GetEventEntry(w, event);

if (entry == smw->simple_menu.entry_set) return;

Unhighlight(w, event, params, num_params);

if (entry == NULL) return;

if ( !XtIsSensitive( (Widget) entry) ) {
    smw->simple_menu.entry_set = NULL;
    return;
}

smw->simple_menu.entry_set = entry;
class = (SmeObjectClass) entry->object.widget_class;

(class->sme_class.highlight) ( (Widget) entry);
}

/*  Function Name: Notify
 *  Description: Notify user of current entry.
 *  Arguments: w - the simple menu widget.
 *              event - the event that caused this action.
 *              params, num_params - ** NOT USED **
 *  Returns: none
 */

/* ARGSUSED */

```

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```

static void
Notify(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry = smw->simple_menu.entry_set;
    SmeObjectClass class;

    if ( (entry == NULL) || !XtIsSensitive((Widget) entry) ) return;

    class = (SmeObjectClass) entry->object.widget_class;
    (class->sme_class.notify)( (Widget) entry );
}

/*  Function Name: Pull
 *   Description: Determines action on basis of leave direction.
 *   Arguments: w - the pull right menu widget.
 *               event - the LeaveWindow event that caused this action.
 *               params, num_params - ** NOT USED **
 *   Returns: none
 */

```

```

static void Pull(w, event, params, num_params)

```

```

Widget      w;
XEvent      *event;
String *params;
Cardinal     *num_params;

```

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```

{
    PullRightMenuWidget    prw=(PullRightMenuWidget)w;
    SmeObject    entry=prw->simple_menu.entry_set;
    SmeObjectClass    class;

    if ((entry == NULL) || !XtIsSensitive((Widget)entry))return;
    if (event->type!=LeaveNotify && event->type!=EnterNotify) {
        XtAppError(XtWidgetToApplicationContext(w),
            "pull() action should only be used with XCrossing events.");
        return;
    }
    if (None!=event->xcrossing.subwindow) return;
    if (event->xcrossing.y<0 || event->xcrossing.y>prw->core.height) {
        Unhighlight(w,event,params,num_params);
        return;
    };
    if (event->xcrossing.x<0) {
        if (XtIsSubclass(XtParent(w),pullRightMenuWidgetClass)) XtPopdown(w);
        return;
    };
    class=(SmeObjectClass)entry->object.widget_class;
    if (event->xcrossing.x>prw->core.width &&
        XtIsSubclass(entry,smeBSBprObjectClass)) (class->sme_class.notify)((Widget)entry);
    else Unhighlight(w,event,params,num_params);
}

```

```

/*    Function Name: Execute
*
*    Description: Determines notify action on basis of SmeObject.
*
*    Arguments: w - the pull right menu widget.
*
*               event - the notify-type event that caused this action.
*
*               params, num_params - ** NOT USED **
*
*    Returns: none

```

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*/

```
static void Execute(w, event, params, num_params)
```

```
Widget      w;
```

```
XEvent      *event;
```

```
String *params;
```

```
Cardinal     *num_params;
```

```
{
```

```
    PullRightMenuWidget    prw=(PullRightMenuWidget)w;
```

```
    SmeObject    entry=prw->simple_menu.entry_set;
```

```
    SmeObjectClass    class;
```

```
    Widget      shell;
```

```
    Dprintf("Execute\n");
```

```
    for(shell=w;XtIsSubclass(shell,pullRightMenuWidgetClass);shell=XtParent(shell))
```

```
    {
```

```
        XawSimpleMenuClearActiveEntry(shell);
```

```
        XtPopdown(shell);
```

```
    };
```

```
    if
```

```
((entry == GetEventEntry(w,event))&&(entry!=NULL)&&XtIsSensitive((Widget)entry)) {
```

```
        class=(SmeObjectClass)entry->object.widget_class;
```

```
        if (XtIsSubclass(entry,smeBSBObjectClass))
```

```
(class->sme_class.notify)((Widget)entry);
```

```
    };
```

```
}
```

```
/******
```

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*

* Public Functions.

*

*****/

```

/*    Function Name: XawPullRightMenuAddGlobalActions
 *    Description: adds the global actions to the simple menu widget.
 *    Arguments: app_con - the appcontext.
 *    Returns: none.
 */

```

void

XawPullRightMenuAddGlobalActions(app_con)

XtAppContext app_con;

{

XtInitializeWidgetClass(pullRightMenuWidgetClass);

XmuCallInitializers(app_con);

}

/*****

*

* Private Functions.

*

*****/

```

/*    Function Name: CreateLabel
 *    Description: Creates a the menu label.
 *    Arguments: w - the smw widget.
 *    Returns: none.
 *
 *    Creates the label object and makes sure it is the first child in
 *    in the list.

```

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*/

static void

CreateLabel(w)

Widget w;

{

SimpleMenuWidget smw = (SimpleMenuWidget) w;

register Widget * child, * next_child;

register int i;

Arg args[2];

if ((smw->simple_menu.label_string == NULL) ||

(smw->simple_menu.label != NULL)) {

char error_buf[BUFSIZ];

sprintf(error_buf, "Xaw Simple Menu Widget: %s or %s, %s",

"label string is NULL", "label already exists",

"no label is being created.");

XtAppWarning(XtWidgetToApplicationContext(w), error_buf);

return;

}

XtSetArg(args[0], XtNlabel, smw->simple_menu.label_string);

XtSetArg(args[1], XtNjustify, XtJustifyCenter);

smw->simple_menu.label = (SmeObject)

XtCreateManagedWidget("menuLabel",

smw->simple_menu.label_class, w,

args, TWO);

next_child = NULL;

for (child = smw->composite.children + smw->composite.num_children,

i = smw->composite.num_children ; i > 0 ; i--, child--) {

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```

    if (next_child != NULL)
        *next_child = *child;
    next_child = child;
}
*child = (Widget) smw->simple_menu.label;
}

```

```

/*  Function Name: Layout
*   Description: lays the menu entries out all nice and neat.
*   Arguments: w - See below (+++)
*               width_ret, height_ret - The returned width and
*                                       height values.
*   Returns: none.
*
* if width == NULL || height == NULL then it assumes the you do not care
* about the return values, and just want a relayout.
*
* if this is not the case then it will set width_ret and height_ret
* to be width and height that the child would get if it were layed out
* at this time.
*
* +++ "w" can be the simple menu widget or any of its object children.
*/

```

```
static void
```

```
Layout(w, width_ret, height_ret)
```

```
Widget w;
```

```
Dimension *width_ret, *height_ret;
```

```
{
```

```
    SmeObject current_entry, *entry;
```

```
    SimpleMenuWidget smw;
```

```
    Dimension width, height;
```


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```
Boolean do_layout = ((height_ret == NULL) || (width_ret == NULL));
```

```
Boolean allow_change_size;
```

```
height = 0;
```

```
if ( XtIsSubclass(w, puliRightMenuWidgetClass) ) {
```

```
    smw = (SimpleMenuWidget) w;
```

```
    current_entry = NULL;
```

```
}
```

```
else {
```

```
    smw = (SimpleMenuWidget) XtParent(w);
```

```
    current_entry = (SmeObject) w;
```

```
}
```

```
allow_change_size = (!XtIsRealized((Widget)smw) ||
```

```
    (smw->shell.allow_shell_resize));
```

```
if ( smw->simple_menu.menu_height )
```

```
    height = smw->core.height;
```

```
else
```

```
    if (do_layout) {
```

```
        height = smw->simple_menu.top_margin;
```

```
        ForAllChildren(smw, entry) {
```

```
            if (!XtIsManaged( (Widget) *entry)) continue;
```

```
            if ( (smw->simple_menu.row_height != 0) &&
```

```
                (*entry != smw->simple_menu.label) )
```

```
                (*entry)->rectangle.height = smw->simple_menu.row_height;
```

```
            (*entry)->rectangle.y = height;
```

```
            (*entry)->rectangle.x = 0;
```

```
            height += (*entry)->rectangle.height;
```

```
}
```

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```

    height += smw->simple_menu.bottom_margin;
}
else {
    if ((smw->simple_menu.row_height != 0) &&
        (current_entry != smw->simple_menu.label) )
        height = smw->simple_menu.row_height;
}

if (smw->simple_menu.menu_width)
    width = smw->core.width;
else if ( allow_change_size )
    width = GetMenuWidth((Widget) smw, (Widget) current_entry);
else
    width = smw->core.width;

if (do_layout) {
    ForAllChildren(smw, entry)
        if (XtIsManaged( (Widget) *entry))
            (*entry)->rectangle.width = width;

    if (allow_change_size)
        MakeSetValuesRequest((Widget) smw, width, height);
}
else {
    *width_ret = width;
    if (height != 0)
        *height_ret = height;
}
}

```

/* Function Name: AddPositionAction

* Description: Adds the XawPositionSimpleMenu action to the global

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```

*           action list for this appcon.
*   Arguments: app_con - the application context for this app.
*           data - NOT USED.
*   Returns: none.
*/

```

```

/* ARGSUSED */

```

```

static void

```

```

AddPositionAction(app_con, data)

```

```

XtAppContext app_con;

```

```

caddr_t data;

```

```

{
    static XtActionsRec pos_action[] = {
        { "XawPositionSimpleMenu", PositionMenuAction },
    };

    XtAppAddActions(app_con, pos_action, XtNumber(pos_action));
}

```

```

/*   Function Name: FindMenu

```

```

*   Description: Find the menu give a name and reference widget.

```

```

*   Arguments: widget - reference widget.

```

```

*           name - the menu widget's name.

```

```

*   Returns: the menu widget or NULL.

```

```

*/

```

```

static Widget

```

```

FindMenu(widget, name)

```

```

Widget widget;

```

```

String name;

```

```

{
    register Widget w, menu;

```

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```

for ( w = widget ; w != NULL ; w = XtParent(w) )
    if ( (menu = XtNameToWidget(w, name)) != NULL )
        return(menu);
return(NULL);
}

```

```

/*    Function Name: PositionMenu
*    Description: Places the menu
*    Arguments: w - the simple menu widget.
*               location - a pointer the the position or NULL.
*    Returns: none.
*/

```

```

static void
PositionMenu(w, location)
Widget w;
XPoint * location;
{
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject entry;
    XPoint t_point;
    static void MoveMenu();

    if (location == NULL) {
        Window junk1, junk2;
        int root_x, root_y, junkX, junkY;
        unsigned int junkM;

        location = &t_point;
        if (XQueryPointer(XtDisplay(w), XtWindow(w), &junk1, &junk2,
            &root_x, &root_y, &junkX, &junkY, &junkM) == FALSE) {

```

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```

    char error_buf[BUFSIZ];
    sprintf(error_buf, "%s %s", "Xaw - SimpleMenuWidget:",
            "Could not find location of mouse pointer");
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}

location->x = (short) root_x;
location->y = (short) root_y;
}

/*
 * The width will not be correct unless it is realized.
 */

XtRealizeWidget(w);

location->x -= (Position) w->core.width/2;

if (smw->simple_menu.popup_entry == NULL)
    entry = smw->simple_menu.label;
else
    entry = smw->simple_menu.popup_entry;

if (entry != NULL)
    location->y -= entry->rectangle.y + entry->rectangle.height/2;

MoveMenu(w, (Position) location->x, (Position) location->y);
}

/*  Function Name: MoveMenu
 *  Description: Actually moves the menu, may force it to
 *               to be fully visable if menu_on_screen is TRUE.

```

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```

*   Arguments: w - the simple menu widget.
*               x, y - the current location of the widget.
*   Returns: none
*/

```

```
static void
```

```
MoveMenu(w, x, y)
```

```
Widget w;
```

```
Position x, y;
```

```
{
```

```
    Arg arglist[2];
```

```
    Cardinal num_args = 0;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    if (smw->simple_menu.menu_on_screen) {
```

```
        int width = w->core.width + 2 * w->core.border_width;
```

```
        int height = w->core.height + 2 * w->core.border_width;
```

```
        if (x < 0)
```

```
            x = 0;
```

```
        else {
```

```
            int scr_width = WidthOfScreen(XtScreen(w));
```

```
            if (x + width > scr_width)
```

```
                x = scr_width - width;
```

```
        }
```

```
        if (y < 0)
```

```
            y = 0;
```

```
        else {
```

```
            int scr_height = HeightOfScreen(XtScreen(w));
```

```
            if (y + height > scr_height)
```

```
                y = scr_height - height;
```

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```

    }
}

XtSetArg(arglist[num_args], XtNx, x); num_args++;
XtSetArg(arglist[num_args], XtNy, y); num_args++;
XtSetValues(w, arglist, num_args);
}

```

```

/*    Function Name: ChangeCursorOnGrab
 *    Description: Changes the cursor on the active grab to the one
 *                specified in our resource list.
 *    Arguments: w - the widget.
 *                junk, garbage - ** NOT USED **.
 *    Returns: None.
 */

```

```

/* ARGSUSED */

```

```

static void

```

```

ChangeCursorOnGrab(w, junk, garbage)

```

```

Widget w;

```

```

caddr_t junk, garbage;

```

```

{

```

```

    SimpleMenuWidget smw = (SimpleMenuWidget) w;

```

```

/*

```

```

 * The event mask here is what is currently in the MIT implementation.
 * There really needs to be a way to get the value of the mask out
 * of the toolkit (CDP 5/26/89).

```

```

*/

```

```

XChangeActivePointerGrab(XtDisplay(w), ButtonPressMask | ButtonReleaseMask,
    smw->simple_menu.cursor, CurrentTime);

```

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}

```

/*  Function Name: MakeSetValuesRequest
*   Description: Makes a (possibly recursive) call to SetValues,
*               I take great pains to not go into an infinite loop.
*   Arguments: w - the simple menu widget.
*               width, height - the size of the ask for.
*   Returns: none
*/

```

static void

MakeSetValuesRequest(w, width, height)

Widget w;

Dimension width, height;

{

SimpleMenuWidget smw = (SimpleMenuWidget) w;

Arg arglist[2];

Cardinal num_args = (Cardinal) 0;

if (!smw->simple_menu.recursive_set_values) {

if ((smw->core.width != width) || (smw->core.height != height)) {

smw->simple_menu.recursive_set_values = TRUE;

XtSetArg(arglist[num_args], XtNwidth, width); num_args++;

XtSetArg(arglist[num_args], XtNheight, height); num_args++;

XtSetValues(w, arglist, num_args);

}

else if (XtIsRealized((Widget) smw))

Redisplay((Widget) smw, (XEvent *) NULL, (Region) NULL);

}

smw->simple_menu.recursive_set_values = FALSE;

}

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```

/*   Function Name: GetMenuWidth
 *   Description: Sets the length of the widest entry in pixels.
 *   Arguments: w - the simple menu widget.
 *   Returns: width of menu.
 */

```

```
static Dimension
```

```
GetMenuWidth(w, w_ent)
```

```
Widget w, w_ent;
```

```
{
```

```
    SmeObject cur_entry = (SmeObject) w_ent;
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    Dimension width, widest = (Dimension) 0;
```

```
    SmeObject * entry;
```

```
    if ( smw->simple_menu.menu_width )
```

```
        return(smw->core.width);
```

```
    ForAllChildren(smw, entry) {
```

```
        XtWidgetGeometry preferred;
```

```
        if (!XtIsManaged( (Widget) *entry)) continue;
```

```
        if (*entry != cur_entry) {
```

```
            XtQueryGeometry(*entry, NULL, &preferred);
```

```
            if (preferred.request_mode & CWWidth)
```

```
                width = preferred.width;
```

```
            else
```

```
                width = (*entry)->rectangle.width;
```

```
        }
```

```
    else
```

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```
width = (*entry)->rectangle.width;
```

```
if ( width > widest )
```

```
    widest = width;
```

```
}
```

```
return(widest);
```

```
}
```

```
/* Function Name: GetMenuHeight
```

```
* Description: Sets the length of the widest entry in pixels.
```

```
* Arguments: w - the simple menu widget.
```

```
* Returns: width of menu.
```

```
*/
```

```
static Dimension
```

```
GetMenuHeight(w)
```

```
Widget w;
```

```
{
```

```
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
```

```
    SmeObject * entry;
```

```
    Dimension height;
```

```
    if (smw->simple_menu.menu_height)
```

```
        return(smw->core.height);
```

```
    height = smw->simple_menu.top_margin + smw->simple_menu.bottom_margin;
```

```
    if (smw->simple_menu.row_height == 0)
```

```
        ForAllChildren(smw, entry)
```

```
            if (XtIsManaged ((Widget) *entry))
```

```
                height += (*entry)->rectangle.height;
```

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```
else
    height += smw->simple_menu.row_height * smw->composite.num_children;

return(height);
}

/*  Function Name: GetEventEntry
 *   Description: Gets an entry given an event that has X and Y coords.
 *   Arguments: w - the simple menu widget.
 *              event - the event.
 *   Returns: the entry that this point is in.
 */
```

```
static SmeObject
GetEventEntry(w, event)
Widget w;
XEvent * event;
{
    Position x_loc, y_loc;
    SimpleMenuWidget smw = (SimpleMenuWidget) w;
    SmeObject * entry;

    switch (event->type) {
    case MotionNotify:
        x_loc = event->xmotion.x;
        y_loc = event->xmotion.y;
        break;
    case EnterNotify:
    case LeaveNotify:
        x_loc = event->xcrossing.x;
        y_loc = event->xcrossing.y;
        break;
```

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```
case ButtonPress:
```

```
case ButtonRelease:
```

```
    x_loc = event->xbutton.x;
```

```
    y_loc = event->xbutton.y;
```

```
    break;
```

```
default:
```

```
    XtAppError(XtWidgetToApplicationContext(w),
```

```
               "Unknown event type in GetEventEntry().");
```

```
    break;
```

```
}
```

```
if ( (x_loc < 0) || (x_loc >= smw->core.width) || (y_loc < 0) ||
```

```
    (y_loc >= smw->core.height) )
```

```
    return(NULL);
```

```
ForAllChildren(smw, entry) {
```

```
    if (!XtIsManaged ((Widget) *entry)) continue;
```

```
    if ( ((*entry)->rectangle.y < y_loc) &&
```

```
        ((*entry)->rectangle.y + (*entry)->rectangle.height > y_loc) )
```

```
        if ( *entry == smw->simple_menu.label )
```

```
            return(NULL);      /* cannot select the label. */
```

```
        else
```

```
            return(*entry);
```

```
}
```

```
return(NULL);
```

```
}
```

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source/Select.c

```

/*
 * Selection from list widget
 *
 */

#include    "../include/xwave.h"

void Select(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Selection    sel=(Selection)closure;
    Widget       button=FindWidget(sel->button,w),
               shell=ShellWidget(sel->name,button,SW_below,NULL,NULL),
               form=FormatWidget("sel_form",shell), list_widget, widgets[3];
    String *list=(sel->list_proc)();
    FormItem     items[]={
        {"sel_cancel","close",0,0,FW_icon,NULL},
        {"sel_label",(String)sel->action_name,1,0,FW_label,NULL},
        {"sel_view",NULL,0,2,FW_view,NULL},
    };
    XtCallbackRec list_calls[]={
        {Destroy,(caddr_t)shell},
        {sel->action_proc,sel->action_closure},
        {NULL,NULL},
    }, callbacks[]={

```

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```
        {Destroy,(caddr_t)shell},  
        {NULL,NULL},  
    };  
    Arg    args[1];  
  
    FillForm(form,THREE,items,widgets,callbacks);  
    XtSetArg(args[0],XtNlist,list);  
  
    list_widget=XtCreateManagedWidget("sel_list",listWidgetClass,widgets[2],args,ONE);  
    XtAddCallbacks(list_widget,XtNcallback,list_calls);  
    XtPopup(shell,XtGrabExclusive);  
}
```

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source/SmeBSBpr.c

#if (!defined(lint) && !defined(SABER))

static char Xrclid[] = "\$XConsortium: SmeBSB.c,v 1.9 89/12/13 15:42:48 kit Exp \$";

#endif

/*

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*/

/*

* SmeBSBpr.c - Source code file for BSB pull-right Menu Entry object.

*

*/

#include <stdio.h>

#include <X11/IntrinsicP.h>

#include <X11/StringDefs.h>

#include <X11/Xmu/Drawing.h>

#include <X11/Xaw/XawInit.h>

#include <X11/Xaw/SimpleMenu.h>

#include "SmeBSBprP.h"

#include <X11/Xaw/Cardinals.h>

#define ONE_HUNDRED 100

#define offset(field) XtOffset(SmeBSBprObject, sme_bsb.field)

static XtResource resources[] = {

{XtNlabel, XtCLabel, XtRString, sizeof(String),
offset(label), XtRString, NULL},{XtNvertSpace, XtCVertSpace, XtRInt, sizeof(int),
offset(vert_space), XtRImmediate, (caddr_t) 25},{XtNleftBitmap, XtCLeftBitmap, XtRPixmap, sizeof(Pixmap),
offset(left_bitmap), XtRImmediate, (caddr_t)None},{XtNjustify, XtCJustify, XtRJustify, sizeof(XtJustify),
offset(justify), XtRImmediate, (caddr_t) XtJustifyLeft},

{XtNrightBitmap, XtCRightBitmap, XtRPixmap, sizeof(Pixmap),

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```

    offset(right_bitmap), XtRImmediate, (caddr_t)None},
    {XtNleftMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
      offset(left_margin), XtRImmediate, (caddr_t) 4},
    {XtNrightMargin, XtCHorizontalMargins, XtRDimension, sizeof(Dimension),
      offset(right_margin), XtRImmediate, (caddr_t) 4},
    {XtNforeground, XtCForeground, XtRPixel, sizeof(Pixel),
      offset(foreground), XtRString, "XtDefaultForeground"},
    {XtNfont, XtCFont, XtRFontStruct, sizeof(XFontStruct *),
      offset(font), XtRString, "XtDefaultFont"},
    {XtNmenuName, XtCMenuName, XtRString, sizeof(String),
      offset(menu_name), XtRString, (caddr_t)"menu"},
};
#endif offset

```

/*

* Semi Public function definitions.

*/

```

static void Redisplay(), Destroy(), Initialize(), FlipColors(), PopupMenu();
static void ClassInitialize();
static Boolean SetValues();
static XtGeometryResult QueryGeometry();

```

/*

* Private Function Definitions.

*/

```

static void GetDefaultSize(), DrawBitmaps(), GetBitmapInfo();
static void CreateGCs(), DestroyGCs();

```

#define superclass (&smeClassRec)

SmeBSBprClassRec smeBSBprClassRec = {

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```

{
/* superclass      */ (WidgetClass) superclass,
/* class_name      */  "SmeBSBpr",
/* size           */   sizeof(SmeBSBprRec),
/* class_initializer */  ClassInitialize,
/* class_part_initialize*/ NULL,
/* Class init'ed    */   FALSE,
/* initialize      */   Initialize,
/* initialize_hook  */   NULL,
/* realize         */   NULL,
/* actions         */   NULL,
/* num_actions     */   ZERO,
/* resources       */   resources,
/* resource_count  */   XtNumber(resources),
/* xrm_class       */   NULLQUARK,
/* compress_motion */   FALSE,
/* compress_exposure */  FALSE,
/* compress_enterleave*/  FALSE,
/* visible_interest */  FALSE,
/* destroy         */   Destroy,
/* resize         */   NULL,
/* expose         */   Redisplay,
/* set_values      */   SetValues,
/* set_values_hook */   NULL,
/* set_values_almost */ XtInheritSetValuesAlmost,
/* get_values_hook */   NULL,
/* accept_focus    */   NULL,
/* intrinsics version */ XtVersion,
/* callback offsets */   NULL,
/* tm_table        */   NULL,
/* query_geometry  */   QueryGeometry,
/* display_accelerator*/  NULL,

```

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```

    /* extension          */  NULL
}, {
    /* Menu Entry Fields */

    /* highlight */          FlipColors,
    /* unhighlight */        FlipColors,
    /* notify */             PopupMenu,
    /* extension          */  NULL
}, {
    /* BSB pull-right Menu entry Fields */

    /* extension          */  NULL
}
};

WidgetClass smeBSBprObjectClass = (WidgetClass) &smeBSBprClassRec;

/*****
 *
 * Semi-Public Functions.
 *
 *****/

/*      Function Name: ClassInitialize
 *      Description: Initializes the SmeBSBprObject.
 *      Arguments: none.
 *      Returns: none.
 */

static void
ClassInitialize()
{

```

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```

XawInitializeWidgetSet();
XtAddConverter( XtRString, XtRJustify, XmuCvtStringToJustify, NULL, 0 );
}

```

```

/*      Function Name: Initialize
 *      Description: Initializes the simple menu widget
 *      Arguments: request - the widget requested by the argument list.
 *                  new     - the new widget with both resource and non-
 *                  resource values.
 *      Returns: none.
 */

```

```

/* ARGSUSED */

```

```

static void

```

```

Initialize(request, new)

```

```

Widget request, new;

```

```

{

```

```

    SmeBSBprObject entry = (SmeBSBprObject) new;

```

```

    if (entry->sme_bsb.label == NULL)

```

```

        entry->sme_bsb.label = XtName(new);

```

```

    else

```

```

        entry->sme_bsb.label = XtNewString( entry->sme_bsb.label );

```

```

    /* Xaw bug - bitmap initialization now performed */

```

```

    if (entry->sme_bsb.left_bitmap != None) GetBitmapInfo(entry, TRUE);

```

```

    if (entry->sme_bsb.right_bitmap != None) GetBitmapInfo(entry, FALSE);

```

```

    CreateGCs(new);

```

```

    GetDefaultSize(new, &(entry->rectangle.width), &(entry->rectangle.height));

```

```

}

```

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```

/*  Function Name: Destroy
 *   Description: Called at destroy time, cleans up.
 *   Arguments: w - the simple menu widget.
 *   Returns: none.
 */

```

```

static void
Destroy(w)
Widget w;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    DestroyGCs(w);
    if (entry->sme_bsb.label != XtName(w))
        XtFree(entry->sme_bsb.label);
}

```

```

/*  Function Name: Redisplay
 *   Description: Redisplays the contents of the widget.
 *   Arguments: w - the simple menu widget.
 *               event - the X event that caused this redisplay.
 *               region - the region the needs to be repainted.
 *   Returns: none.
 */

```

```

/* ARGSUSED */

```

```

static void
Redisplay(w, event, region)
Widget w;
XEvent * event;
Region region;
{

```

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GC gc;

SmeBSBprObject entry = (SmeBSBprObject) w;

int font_ascent, font_descent, y_loc;

entry->sme_bsb.set_values_area_cleared = FALSE;

font_ascent = entry->sme_bsb.font->max_bounds.ascent;

font_descent = entry->sme_bsb.font->max_bounds.descent;

y_loc = entry->rectangle.y;

if (XtIsSensitive(w) && XtIsSensitive(XtParent(w))) {

if (w == XawSimpleMenuGetActiveEntry(XtParent(w))) {

XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),

entry->sme_bsb.norm_gc, 0, y_loc,

(unsigned int) entry->rectangle.width,

(unsigned int) entry->rectangle.height);

gc = entry->sme_bsb.rev_gc;

}

else

gc = entry->sme_bsb.norm_gc;

}

else

gc = entry->sme_bsb.norm_gray_gc;

if (entry->sme_bsb.label != NULL) {

int x_loc = entry->sme_bsb.left_margin;

int len = strlen(entry->sme_bsb.label);

char * label = entry->sme_bsb.label;

switch(entry->sme_bsb.justify) {

int width, t_width;

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```
case XtJustifyCenter:
```

```
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
```

```
    width = entry->rectangle.width - (entry->sme_bsb.left_margin +
                                      entry->sme_bsb.right_margin);
```

```
    x_loc += (width - t_width)/2;
```

```
    break;
```

```
case XtJustifyRight:
```

```
    t_width = XTextWidth(entry->sme_bsb.font, label, len);
```

```
    x_loc = entry->rectangle.width - (entry->sme_bsb.right_margin +
                                      t_width);
```

```
    break;
```

```
case XtJustifyLeft:
```

```
default:
```

```
    break;
```

```
}
```

```
y_loc += (entry->rectangle.height -
          (font_ascent + font_descent)) / 2 + font_ascent;
```

```
XDrawString(XtDisplayOfObject(w), XtWindowOfObject(w), gc,
            x_loc, y_loc, label, len);
```

```
}
```

```
DrawBitmaps(w, gc);
```

```
}
```

```
/* Function Name: SetValues
```

```
* Description: Relayout the menu when one of the resources is changed.
```

```
* Arguments: current - current state of the widget.
```

```
*           request - what was requested.
```

```
*           new - what the widget will become.
```

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* Returns: none

*/

/* ARGSUSED */

static Boolean

SetValues(current, request, new)

Widget current, request, new;

{

SmeBSBprObject entry = (SmeBSBprObject) new;

SmeBSBprObject old_entry = (SmeBSBprObject) current;

Boolean ret_val = FALSE;

if (old_entry->sme_bsb.label != entry->sme_bsb.label) {

if (old_entry->sme_bsb.label != XtName(new))

XtFree((char *) old_entry->sme_bsb.label);

if (entry->sme_bsb.label != XtName(new))

entry->sme_bsb.label = XtNewString(entry->sme_bsb.label);

ret_val = True;

}

if (entry->rectangle.sensitive != old_entry->rectangle.sensitive)

ret_val = TRUE;

if (entry->sme_bsb.left_bitmap != old_entry->sme_bsb.left_bitmap) {

GetBitmapInfo(new, TRUE);

ret_val = TRUE;

}

if (entry->sme_bsb.right_bitmap != old_entry->sme_bsb.right_bitmap) {

GetBitmapInfo(new, FALSE);

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```

    ret_val = TRUE;
}

if ( (old_entry->sme_bsb.font != entry->sme_bsb.font) ||
      (old_entry->sme_bsb.foreground != entry->sme_bsb.foreground) ) {
    DestroyGCs(current);
    CreateGCs(new);
    ret_val = TRUE;
}

if (ret_val) {
    GetDefaultSize(new,
                   &(entry->rectangle.width), &(entry->rectangle.height));
    entry->sme_bsb.set_values_area_cleared = TRUE;
}

return(ret_val);
}

/*  Function Name: QueryGeometry.
 *   Description: Returns the preferred geometry for this widget.
 *   Arguments: w - the menu entry object.
 *              intended, return_val - the intended and return geometry info.
 *   Returns: A Geometry Result.
 *
 *   See the Intrinsics manual for details on what this function is for.
 *
 *   I just return the height and width of the label plus the margins.
 */

```

```

static XtGeometryResult
QueryGeometry(w, intended, return_val)
Widget w;

```

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```
XtWidgetGeometry *intended, *return_val;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;
    Dimension width, height;
    XtGeometryResult ret_val = XtGeometryYes;
    XtGeometryMask mode = intended->request_mode;

    GetDefaultSize(w, &width, &height );

    if ( ((mode & CWWidth) && (intended->width != width)) ||
        !(mode & CWWidth) ) {
        return_val->request_mode |= CWWidth;
        return_val->width = width;
        ret_val = XtGeometryAlmost;
    }

    if ( ((mode & CWHeight) && (intended->height != height)) ||
        !(mode & CWHeight) ) {
        return_val->request_mode |= CWHeight;
        return_val->height = height;
        ret_val = XtGeometryAlmost;
    }

    if (ret_val == XtGeometryAlmost) {
        mode = return_val->request_mode;

        if ( ((mode & CWWidth) && (width == entry->rectangle.width)) &&
            ((mode & CWHeight) && (height == entry->rectangle.height)) )
            return(XtGeometryNo);
    }

    return(ret_val);
}
```

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}

```

/*  Function Name: FlipColors
 *   Description: Invert the colors of the current entry.
 *   Arguments: w - the bsb menu entry widget.
 *   Returns: none.
 */

```

static void

FlipColors(w)

Widget w;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

if (entry->sme_bsb.set_values_area_cleared) return;

XFillRectangle(XtDisplayOfObject(w), XtWindowOfObject(w),

entry->sme_bsb.invert_gc, 0, (int) entry->rectangle.y,

(unsigned int) entry->rectangle.width,

(unsigned int) entry->rectangle.height);

}

/*****

*

* Private Functions.

*

*****/

/* Function Name: GetDefaultSize

```

 *   Description: Calculates the Default (preferred) size of
 *               this menu entry.

```

```

 *   Arguments: w - the menu entry widget.

```

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```

*           width, height - default sizes (RETURNED).
*   Returns: none.
*/

```

```
static void
```

```
GetDefaultSize(w, width, height)
```

```
Widget w;
```

```
Dimension * width, * height;
```

```

{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    if (entry->sme_bsb.label == NULL)
        *width = 0;
    else
        *width = XTextWidth(entry->sme_bsb.font, entry->sme_bsb.label,
                           strlen(entry->sme_bsb.label));

    *width += entry->sme_bsb.left_margin + entry->sme_bsb.right_margin;

    *height = (entry->sme_bsb.font->max_bounds.ascent +
               entry->sme_bsb.font->max_bounds.descent);

    *height = (*height * ( ONE_HUNDRED +
                           entry->sme_bsb.vert_space )) / ONE_HUNDRED;
}

```

```
/*   Function Name: DrawBitmaps
```

```
*   Description: Draws left and right bitmaps.
```

```
*   Arguments: w - the simple menu widget.
```

```
*           gc - graphics context to use for drawing.
```

```
*   Returns: none
```

```
*/
```

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```

static void
DrawBitmaps(w, gc)
Widget w;
GC gc;
{
    int x_loc, y_loc;
    SmeBSBprObject entry = (SmeBSBprObject) w;

    if ( (entry->sme_bsb.left_bitmap == None) &&
        (entry->sme_bsb.right_bitmap == None) ) return;

    /*
     * Draw Left Bitmap.
     */

    y_loc = entry->rectangle.y + (entry->rectangle.height -
                                   entry->sme_bsb.left_bitmap_height) / 2;

    if (entry->sme_bsb.left_bitmap != None) {
        x_loc = (entry->sme_bsb.left_margin -
                 entry->sme_bsb.left_bitmap_width) / 2;
        XCopyPlane(XtDisplayOfObject(w), entry->sme_bsb.left_bitmap,
                   XtWindowOfObject(w), gc, 0, 0,
                   entry->sme_bsb.left_bitmap_width,
                   entry->sme_bsb.left_bitmap_height, x_loc, y_loc, 1);
    }

    /*
     * Draw Right Bitmap.
     */

    y_loc = entry->rectangle.y + (entry->rectangle.height - /* Xaw bug - y_loc

```

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calculated from right_bitmap data */

entry->sme_bsb.right_bitmap_height) / 2;

if (entry->sme_bsb.right_bitmap != None) {

x_loc = entry->rectangle.width - (entry->sme_bsb.right_margin + /* Xaw bug - +
rather than - sign */

entry->sme_bsb.right_bitmap_width) / 2;

XCopyPlane(XtDisplayOfObject(w), entry->sme_bsb.right_bitmap,

XtWindowOfObject(w), gc, 0, 0,

entry->sme_bsb.right_bitmap_width,

entry->sme_bsb.right_bitmap_height, x_loc, y_loc, 1);

}

}

/* Function Name: GetBitmapInfo

* Description: Gets the bitmap information from either of the bitmaps.

* Arguments: w - the bsb menu entry widget.

* is_left - TRUE if we are testing left bitmap,

* FALSE if we are testing the right bitmap.

* Returns: none

*/

static void

GetBitmapInfo(w, is_left)

Widget w;

Boolean is_left;

{

SmeBSBprObject entry = (SmeBSBprObject) w;

unsigned int depth, bw;

Window root;

int x, y;

unsigned int width, height;

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```

char buf[BUFSIZ];

if (is_left) {
    if (entry->sme_bsb.left_bitmap != None) {
        if (!XGetGeometry(XtDisplayOfObject(w),
            entry->sme_bsb.left_bitmap, &root,
            &x, &y, &width, &height, &bw, &depth)) {
            sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
                "get Left Bitmap geometry information for menu entry ",
                XtName(w));
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        if (depth != 1) {
            sprintf(buf, "SmeBSB Object: %s \"%s\"%s.",
                "Left Bitmap of entry ",
                XtName(w), " is not one bit deep.");
            XtAppError(XtWidgetToApplicationContext(w), buf);
        }
        entry->sme_bsb.left_bitmap_width = (Dimension) width;
        entry->sme_bsb.left_bitmap_height = (Dimension) height;
    }
}

else if (entry->sme_bsb.right_bitmap != None) {
    if (!XGetGeometry(XtDisplayOfObject(w),
        entry->sme_bsb.right_bitmap, &root,
        &x, &y, &width, &height, &bw, &depth)) {
        sprintf(buf, "SmeBSB Object: %s %s \"%s\".", "Could not",
            "get Right Bitmap geometry information for menu entry ",
            XtName(w));
        XtAppError(XtWidgetToApplicationContext(w), buf);
    }
    if (depth != 1) {

```

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```
sprintf(buf, "SmeBSB Object: %s\ \"%s\ \"%s.",
```

```
    "Right Bitmap of entry ", XtName(w),
```

```
    " is not one bit deep.");
```

```
XtAppError(XtWidgetToApplicationContext(w), buf);
```

```
}
```

```
entry->sme_bsb.right_bitmap_width = (Dimension) width;
```

```
entry->sme_bsb.right_bitmap_height = (Dimension) height;
```

```
}
```

```
}
```

```
/* Function Name: CreateGCs
```

```
* Description: Creates all gc's for the simple menu widget.
```

```
* Arguments: w - the simple menu widget.
```

```
* Returns: none.
```

```
*/
```

```
static void
```

```
CreateGCs(w)
```

```
Widget w;
```

```
{
```

```
    SmeBSBprObject entry = (SmeBSBprObject) w;
```

```
    XGCValues values;
```

```
    XtGCMask mask;
```

```
    values.foreground = XtParent(w)->core.background_pixel;
```

```
    values.background = entry->sme_bsb.foreground;
```

```
    values.font = entry->sme_bsb.font->fid;
```

```
    values.graphics_exposures = FALSE;
```

```
    mask = GCForeground | GCBackground | GCFont | GCGraphicsExposures;
```

```
    entry->sme_bsb.rev_gc = XtGetGC(w, mask, &values);
```

```
    values.foreground = entry->sme_bsb.foreground;
```


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```

values.background = XtParent(w)->core.background_pixel;
entry->sme_bsb.norm_gc = XtGetGC(w, mask, &values);

values.fill_style = FillTiled;
values.tile = XmuCreateStippledPixmap(XtScreenOfObject(w),
                                     entry->sme_bsb.foreground,
                                     XtParent(w)->core.background_pixel,
                                     XtParent(w)->core.depth);

values.graphics_exposures = FALSE;
mask |= GCTile | GCFillStyle;
entry->sme_bsb.norm_gray_gc = XtGetGC(w, mask, &values);

values.foreground ^= values.background;
values.background = 0;
values.function = GXxor;
mask = GCForeground | GCBackground | GCGraphicsExposures | GCFunction;
entry->sme_bsb.invert_gc = XtGetGC(w, mask, &values);
}

/*  Function Name: DestroyGCs
 *  Description: Removes all gc's for the simple menu widget.
 *  Arguments: w - the simple menu widget.
 *  Returns: none.
 */

static void
DestroyGCs(w)
Widget w;
{
    SmeBSBprObject entry = (SmeBSBprObject) w;

    XtReleaseGC(w, entry->sme_bsb.norm_gc);

```

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```
XtReleaseGC(w, entry->sme_bsb.norm_gray_gc);
XtReleaseGC(w, entry->sme_bsb.rev_gc);
XtReleaseGC(w, entry->sme_bsb.invert_gc);
}

#ifdef apollo

/*
 * The apollo compiler that we have optimizes out my code for
 * FlipColors() since it is static. and no one executes it in this
 * file. I am setting the function pointer into the class structure so
 * that it can be called by my parent who will tell me to when to
 * highlight and unhighlight.
 */

void _XawSmeBSBApolloHack ()
{
    FlipColors();
}

#endif /* apollo */

/* Hacked copy of PopupMenu from MenuButton widget to replace XtInheritNotify */

static void
PopupMenu(w, event, params, num_params)
Widget w;
XEvent * event;
String * params;
Cardinal * num_params;
{
    SmeBSBprObject mbw = (SmeBSBprObject) w;
    Widget menu, temp;
```

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```
Arg arglist[2];
Cardinal num_args;
int menu_x, menu_y, menu_width, menu_height, button_width, button_height;
Position button_x, button_y;

temp = XtParent(w); /* Shell not menu entry is parent of menu */
while(temp != NULL) {
    menu = XtNameToWidget(temp, mbw->sme_bsb.menu_name);
    if (menu == NULL)
        temp = XtParent(temp);
    else
        break;
}

if (menu == NULL) {
    char error_buf[BUFSIZ];
    sprintf(error_buf, "MenuButton: %s %s.",
            "Could not find menu widget named", mbw->sme_bsb.menu_name);
    XtAppWarning(XtWidgetToApplicationContext(w), error_buf);
    return;
}
if (!XtIsRealized(menu))
    XtRealizeWidget(menu);

menu_width = menu->core.width + 2 * menu->core.border_width;
button_width = w->core.width + 2 * w->core.border_width;
button_height = w->core.height + 2 * w->core.border_width;

menu_height = menu->core.height + 2 * menu->core.border_width;

XtTranslateCoords(w, 0, 0, &button_x, &button_y);
menu_x = button_x + button_width;
```

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```
menu_y = button_y;

if (menu_x < 0)
    menu_x = 0;
else {
    int scr_width = WidthOfScreen(XtScreen(menu));
    if (menu_x + menu_width > scr_width)
        menu_x = scr_width - menu_width;
}

if (menu_y < 0)
    menu_y = 0;
else {
    int scr_height = HeightOfScreen(XtScreen(menu));
    if (menu_y + menu_height > scr_height)
        menu_y = scr_height - menu_height;
}

num_args = 0;
XtSetArg(arglist[num_args], XtNx, menu_x); num_args++;
XtSetArg(arglist[num_args], XtNy, menu_y); num_args++;
XtSetValues(menu, arglist, num_args);

XtPopupSpringLoaded(menu);
}
```

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source/Storage.c

```

/*
    Routines to allow video frames to be stored in memory
    or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,
    CopyHeader.
*/

```

```

#include    "../include/xwave.h"

```

```

extern FILE *zopen();

```

```

extern void zseek();

```

```

extern void zclose();

```

```

void NewFrame(vid,number)

```

```

Video vid;

```

```

int number;

```

```

{

```

```

    if (vid->data[0][number] == NULL) {

```

```

        int channel, channels=vid->type==MONO?1:3;

```

```

        for(channel=0;channel<channels;channel++)

```

```

            vid->data[channel][number]=(short

```

```

            *)MALLOC(sizeof(short)*Size(vid,channel,0)*Size(vid,channel,1));

```

```

        }

```

```

    }

```

```

void GetFrame(vid,number)

```

```

Video vid;

```

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```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int      pid, r, c, channel,
                start=vid->x_offset+vid->cols*vid->y_offset,

end=(vid->rows-vid->y_offset-vid->size[1])*vid->cols-vid->x_offset,
        inter=vid->cols-vid->size[0];

        NewFrame(vid,number);

        sprintf(file_name,"%s%s/%s/%s%03d\0",global->home,IMAGE_DIR,vid->path,vid->files[0] == '\0'?vid->name:vid->files,number+vid->start);
        Dprintf("Reading file %s\n",file_name);
        fp=zopen(file_name,&pid);
        if (vid->precision == 0) whole_frame=(char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp,vid->offset);
        for(channel=0;channel<(vid->type==MONO?1:3);channel++) {
            int    shift[2]={vid->type==YUV &&
channel!=0?vid->UVsample[0]:0,vid->type==YUV &&
channel!=0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n",channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame,sizeof(char),(vid->cols>>shift[0])*(vid->rows>>shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n",file_name);

```

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```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r<vid->size[1]>>shift[1];r++)
        for(c=0;c<vid->size[0]>>shift[0];c++) {
            short
            pel=cti(whole_frame[(vid->x_offset>>shift[0])+c+((vid->y_offset>>shift[1])+r)*
            vid->cols>>shift[0]]);

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=vid->negative?-1-pel:pel;
        }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r<vid->size[1]>>shift[1];r++) {

if(0==fread(&(vid->data[channel][number][r*(vid->size[0]>>shift[0])]),sizeof(short),
vid->size[0]>>shift[0],fp)) {

            Dprintf("Error whilst reading

%s\n",file_name);

            Eprintf("Error whilst reading

%s\n",file_name);

        }
        if (inter!=0) zseek(fp,inter*sizeof(short));
        if (vid->negative)
            for(c=0;c<vid->size[0]>>shift[0];c++)

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=-1-vid->data[channel][nu
mber][c+r*(vid->size[0]>>shift[0])];

```

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source/Storage.c

/*

Routines to allow video frames to be stored in memory

or on disk: NewFrame, GetFrame, SaveFrame, FreeFrame, SaveHeader,

CopyHeader.

*/

#include "../include/xwave.h"

extern FILE *zopen();

extern void zseek();

extern void zclose();

void NewFrame(vid,number)

Video vid;

int number;

{

if (vid->data[0][number] == NULL) {

int channel, channels=vid->type==MONO?1:3;

for(channel=0;channel<channels;channel++)

vid->data[channel][number]=(short

*)MALLOC(sizeof(short)*Size(vid,channel,0)*Size(vid,channel,1));

}

}

void GetFrame(vid,number)

Video vid;

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```

int    number;

{
    if (vid->data[0][number] == NULL) {
        char    file_name[STRLEN], *whole_frame;
        FILE    *fp, *fopen();
        int     pid, r, c, channel,
                start=vid->x_offset+vid->cols*vid->y_offset,

end=(vid->rows-vid->y_offset-vid->size[1])*vid->cols-vid->x_offset,
        inter=vid->cols-vid->size[0];

        NewFrame(vid,number);

        sprintf(file_name, "%s%s/%s/%s%03d\0", global->home, IMAGE_DIR, vid->path, vid->files[0] == '\0'?vid->name:vid->files, number+vid->start);
        Dprintf("Reading file %s\n", file_name);
        fp=zopen(file_name, &pid);
        if (vid->precision == 0) whole_frame=(char
*)MALLOC(vid->rows*vid->cols);
        zseek(fp, vid->offset);
        for(channel=0; channel < (vid->type == MONO?1:3); channel++) {
            int    shift[2]={vid->type == YUV &&
channel!=0?vid->UVsample[0]:0, vid->type == YUV &&
channel!=0?vid->UVsample[1]:0};

            Dprintf("Reading channel %d\n", channel);
            if (vid->precision == 0) {

if(0 == fread(whole_frame, sizeof(char), (vid->cols >> shift[0])*(vid->rows >> shift[1]),
fp)) {

                Dprintf("Error whilst reading %s\n", file_name);

```

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```

        Eprintf("Error whilst reading %s\n",file_name);
    }
    for(r=0;r<vid->size[1]>>shift[1];r++)
        for(c=0;c<vid->size[0]>>shift[0];c++) {
            short
            pel=cti(whole_frame[(vid->x_offset>>shift[0])+c+((vid->y_offset>>shift[1])+r)*(
            vid->cols>>shift[0])));

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=vid->negative?-1-pel:pel;
        }
    } else {
        if (start!=0) zseek(fp,start*sizeof(short));
        for(r=0;r<vid->size[1]>>shift[1];r++) {

if(0==fread(&(vid->data[channel][number][r*(vid->size[0]>>shift[0])]),sizeof(short),
vid->size[0]>>shift[0],fp)) {

            Dprintf("Error whilst reading

%s\n",file_name);

            Eprintf("Error whilst reading

%s\n",file_name);

        }
        if (inter!=0) zseek(fp,inter*sizeof(short));
        if (vid->negative)
            for(c=0;c<vid->size[0]>>shift[0];c++)

vid->data[channel][number][c+r*(vid->size[0]>>shift[0])]=-1-vid->data[channel][nu
mber][c+r*(vid->size[0]>>shift[0])];

```

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}

```
void SaveHeader(vid)
```

```
Video vid;
```

{

```
FILE *fp, *fopen();
```

```
char file_name[STRLEN];
```

```
String types[]={"MONO","RGB","YUV"};
```

```
Dprintf("SaveHeader %s\n",vid->name);
```

```
sprintf(file_name,"%s%s/%s%s\0",global->home,VID_DIR,vid->name,VID_EXT);
```

```
fp=fopen(file_name,"w");
```

```
fprintf(fp,"Path \" %s\" \n",vid->path);
```

```
if (vid->files[0]!='\0') fprintf(fp,"Files \" %s\" \n",vid->files);
```

```
if (vid->type==YUV) fprintf(fp,"Type %s %d  
%d\n",types[vid->type],vid->UVsample[0],vid->UVsample[1]);
```

```
else fprintf(fp,"Type %s\n",types[vid->type]);
```

```
if (vid->rate!=0) fprintf(fp,"Rate %d\n",vid->rate);
```

```
if (vid->disk) fprintf(fp,"Disk\n");
```

```
if (vid->gamma) fprintf(fp,"Gamma\n");
```

```
fprintf(fp,"Start %03d\n",vid->start);
```

```
fprintf(fp,"Length %d\n",vid->size[2]);
```

```
fprintf(fp,"Dimensions %d %d\n",vid->cols,vid->rows);
```

```
switch(vid->trans.type) {
```

```
case TRANS_None: fprintf(fp,"Transform None\n"); break;
```

```
case TRANS_Wave: fprintf(fp,"Transform Wavelet %d %d
```

```
%s\n",vid->trans.wavelet.space[0],vid->trans.wavelet.space[1],vid->trans.wavelet.dirn
```

```
?"Yes":"No"); break;
```

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```

    }
    fprintf(fp, "Header %d\n", vid->offset);
    fprintf(fp, "Offsets %d %d\n", vid->x_offset, vid->y_offset);
    fprintf(fp, "Size %d %d\n", vid->size[0], vid->size[1]);
    fprintf(fp, "Precision %d\n", vid->precision);
    fclose(fp);
}

```

Video CopyHeader(src)

Video src;

```

{
    Video dst=(Video)MALLOC(sizeof(VideoRec));
    int    channel;

    Dprintf("CopyHeader %s\n",src);
    strcpy(dst->path,src->path);
    strcpy(dst->name,src->name);
    dst->type=src->type;
    dst->disk=src->disk;
    dst->gamma=src->gamma;
    dst->negative=False;
    dst->rate=src->rate;
    dst->start=src->start;
    dst->size[0]=src->size[0];
    dst->size[1]=src->size[1];
    dst->size[2]=src->size[2];
    dst->UVsample[0]=src->UVsample[0];
    dst->UVsample[1]=src->UVsample[1];
    dst->offset=0;
    dst->cols=src->size[0];
}

```

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```
dst->rows=src->size[1];
dst->x_offset=0;
dst->y_offset=0;
dst->trans=src->trans;
dst->precision=src->precision;
for(channel=0;channel<(src->type==MONO?1:3);channel++)
    dst->data[channel]=(short **)MALLOC(src->size[2]*sizeof(short *));
return(dst);
}
```

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source/Transform.c

```

/*
    Transform video using wavelet transform
*/

#include    "xwave.h"
#include    "Transform.h"
extern short Round();

void DropVideo(w,closure,call_data)

Widget      w;
caddr_t      closure, call_data;

{
    Video video=global->videos->next;
    int    frame, channel;

    for(channel=0;channel<(global->videos->type==MONO?1:(global->videos->type==YUV?3:4));channel++)
        if (global->videos->data[channel]!=NULL) {
            for (frame=0;frame<global->videos->size[2];frame++)
                if (global->videos->data[channel][frame]!=NULL)
                    XtFree(global->videos->data[channel][frame]);
            XtFree(global->videos->data[channel]);
        }
    XtFree(global->videos);
    global->videos=video;
}

```

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}

```
void ChangePrecision(src,dst,frame,old,new)
```

```
Video src, dst;
```

```
int frame, old, new;
```

{

```
int channel, i;
```

```
if(src!=dst || old!=new) {
```

```
int shift=new-old;
```

```
Dprintf("Changing precision %d to %d for frame %d\n",old,new,frame);
```

```
for (channel=0;channel<(src->type==MONO?1:3);channel++) {
```

```
int size=Size(src,channel,0)*Size(src,channel,1);
```

```
for(i=0;i<size;i++)
```

```
dst->data[channel][frame][i]=shift<0?Round(src->data[channel][frame][i],-shift):(shift
==0?src->data[channel][frame][i]:src->data[channel][frame][i]<<shift);
```

```
}
```

```
}
```

}

```
void TransformCtrl(w,closure,call_data)
```

```
Widget w;
```

```
caddr_t closure, call_data;
```

{

```
TransCtrl ctrl=(TransCtrl)closure;
```

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```

Video src=ctrl->src, dst=CopyHeader(src);
long i, frame, channel;

Dprintf("TransformCtrl\n");
strcpy(dst->name,ctrl->name);
dst->trans.type=TRANS_Wave;
dst->trans.wavelet.space[0]=ctrl->space[0];
dst->trans.wavelet.space[1]=ctrl->space[1];
dst->trans.wavelet.dirn=ctrl->dirn;
dst->precision=ctrl->precision;
strcpy(dst->files,dst->name);
if (dst->disk) SaveHeader(dst);
if (src->trans.type!=TRANS_Wave) {
    src->trans.type=TRANS_Wave;
    src->trans.wavelet.space[0]=0;
    src->trans.wavelet.space[1]=0;
}

if (src->trans.wavelet.space[0]!=dst->trans.wavelet.space[0] ||
src->trans.wavelet.space[1]!=dst->trans.wavelet.space[1])
    for(frame=0;frame<dst->size[2];frame++) {
        int
max_precision=src->precision>dst->precision?src->precision:dst->precision;

        Dprintf("Processing frame %d\n",frame);
        NewFrame(dst,frame);
        GetFrame(src,frame);
        ChangePrecision(src,dst,frame,src->precision,max_precision);
        for (channel=0;channel<(src->type==MONO?1:3);channel++)
        {
            int oct_src=src->trans.wavelet.space[channel==0?0:1],

```


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```
oct_dst=dst->trans.wavelet.space[channel==0?0:1],
```

```
size[2]={Size(dst,channel,0),Size(dst,channel,1)};
```

```
if (oct_src!=oct_dst)
```

```
Convolve(dst->data[channel][frame],ctrl->dirn,size,oct_src,oct_dst);
```

```
}
```

```
ChangePrecision(dst,dst,frame,max_precision,dst->precision);
```

```
SaveFrame(dst,frame);
```

```
FreeFrame(dst,frame);
```

```
FreeFrame(src,frame);
```

```
}
```

```
if (src->trans.wavelet.space[0]==0 && src->trans.wavelet.space[1]==0)
```

```
src->trans.type=TRANS_None;
```

```
if (dst->trans.wavelet.space[0]==0 && dst->trans.wavelet.space[1]==0) {
```

```
dst->trans.type=TRANS_None;
```

```
if (dst->disk) SaveHeader(dst);
```

```
}
```

```
dst->next=global->videos;
```

```
global->videos=dst;
```

```
}
```

```
void Transtype(w,closure,call_data)
```

```
Widget w;
```

```
caddr_t closure, call_data;
```

```
{
```

```
Video vid=(Video)closure;
```

```
if (vid->trans.wavelet.space[0]==0 && vid->trans.wavelet.space[1]==0)
```

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```
vid->trans.type=TRANS_None;
}
```

```
void BatchTransCtrl(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
    TransCtrl ctrl=(TransCtrl)closure;

    if (ctrl->src == NULL) ctrl->src=FindVideo(ctrl->src_name,global->videos);
    if (ctrl->src->trans.type==TRANS_Wave)
ctrl->dirn=ctrl->src->trans.wavelet.dirn;
    TransformCtrl(w,closure,call_data);
}
```

```
TransCtrl InitTransCtrl(name)
```

```
String name;
```

```
{
    TransCtrl ctrl=(TransCtrl)MALLOC(sizeof(TransCtrlRec));

    strcpy(ctrl->src_name,name);
    strcpy(ctrl->name,name);
    ctrl->dirn=False;
    Dprintf("Transform\n");
    return(ctrl);
}
```

```
#define TRANS_ICONS 16
```

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```

void Transform(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    Video video=(Video)closure;
    TransCtrl ctrl=InitTransCtrl(video->name);
    NumInput spaceInput=(NumInput)MALLOC(2*sizeof(NumInputRec)),
        precInput=(NumInput)MALLOC(sizeof(NumInputRec));
    Message msg=NewMessage(ctrl->name,NAME_LEN);
    XtCallbackRec destroy_call[]={
        {Free,(caddr_t)ctrl},
        {Free,(caddr_t)spaceInput},
        {Free,(caddr_t)precInput},
        {CloseMessage,(caddr_t)msg},
        {NULL,NULL},
    };
    Widget parent=FindWidget("frm_transform",XtParent(w)),

    shell=ShellWidget("transform",parent,SW_below,NULL,destroy_call),
        form=FormatWidget("trans_form",shell),
    widgets[TRANS_ICONS];
    FormItem items[]={
        {"trans_cancel","cancel",0,0,FW_icon,NULL},
        {"trans_confirm","confirm",1,0,FW_icon,NULL},
        {"trans_title","Transform a video",2,0,FW_label,NULL},
        {"trans_vid_lab","Video Name:",0,3,FW_label,NULL},
        {"trans_video",NULL,4,3,FW_text,(String)msg},

        {"trans_dirn_lab","Direction:",0,4,FW_label,NULL},
        {"trans_dirn",NULL,4,4,FW_yn,(String)&ctrl->dirn},
    };
}

```

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```

{"trans_bits_int",NULL,0,6,FW_integer,(String)precInput},
{"trans_bits_down",NULL,4,6,FW_down,(String)precInput},
{"trans_bits_up",NULL,9,6,FW_up,(String)precInput},

{"trans_spc0_int",NULL,0,8,FW_integer,(String)&spaceInput[0]},
{"trans_spc0_down",NULL,4,8,FW_down,(String)&spaceInput[0]},
{"trans_spc0_up",NULL,12,8,FW_up,(String)&spaceInput[0]},
{"trans_spc1_int",NULL,0,11,FW_integer,(String)&spaceInput[1]},
{"trans_spc1_down",NULL,4,11,FW_down,(String)&spaceInput[1]},

{"trans_spc1_up",NULL,15,11,FW_up,(String)&spaceInput[1]},
};

XtCallbackRec      callbacks[]={
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {TransformCtrl,(caddr_t)ctrl},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
    {ChangeYN,(caddr_t)&ctrl->dirn}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)precInput}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[0]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
    {NumIncDec,(caddr_t)&spaceInput[1]}, {NULL,NULL},
};

Dprintf("Transform\n");
msg->rows=1; msg->cols=NAME_LEN;
ctrl->src=video;
if (video->trans.type==TRANS_Wave) {
    ctrl->space[0]=video->trans.wavelet.space[0];

```

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```

ctrl->space[1]=video->trans.wavelet.space[1];
ctrl->dirn=video->trans.wavelet.dirn;
} else {
    ctrl->space[0]=0; ctrl->space[1]=0;
    ctrl->dirn=False;
}
ctrl->precision=video->precision;

spaceInput[0].format=video->type==YUV?"Y-Space: %d":"Space: %d";
spaceInput[0].max=100;
spaceInput[0].min=0;
spaceInput[0].value=&ctrl->space[0];
if (video->type==YUV) {
    spaceInput[1].format="UV-Space: %d";
    spaceInput[1].max=100;
    spaceInput[1].min=0;
    spaceInput[1].value=&ctrl->space[1];
}
precInput->format="Precision: %d";
precInput->max=16;
precInput->min=0;
precInput->value=&ctrl->precision;

```

```

FillForm(form,TRANS_ICONS-(video->type==YUV?0:3),items,widgets,callbacks);
if (video->trans.type==TRANS_Wave) XtSetSensitive(widgets[6],False);
XtPopup(shell,XtGrabExclusive);
}

```

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source/Update.c

```
/*  
    Update Image, Info and InfoText from positional information  
*/
```

```
#include    "../include/xwave.h"  
#include    <varargs.h>  
extern int  CompositePixel();  
extern int  Dither();  
extern short Round();  
extern int  ReMap();  
extern Palette FindPalette();
```

```
char  *ResizeData(size)
```

```
int    size;
```

```
{
```

```
    static char    *data=NULL;
```

```
    static int     data_size=0;
```

```
    if (size!=data_size) {
```

```
        Dprintf("New frame memory\n");
```

```
        if (data!=NULL) XtFree(data);
```

```
        data=(char *)MALLOC(size);
```

```
        data_size=size;
```

```
    }
```

```
    return(data);
```

```
}
```

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Pixmap UpdateImage(frame)

Frame frame;

{

int x, y, i;

Display *dpy=XtDisplay(global->toplevel);

void CvtIndex(), UpdatePoint();

Palette pal=FindPalette(global->palettes,frame->palette);

Video vid=frame->video;

int scrn=XDefaultScreen(dpy), depth=DisplayPlanes(dpy,scrn),

size[2]={Size(vid,frame->channel,0),Size(vid,frame->channel,1)},

img_size[2]={size[0]<<frame->zoom,size[1]<<frame->zoom},

bpl=(img_size[0]*depth+7)/8, new_size=img_size[1]*bpl,

space=vid->trans.wavelet.space[vid->type]==YUV &&

frame->channel!=0 && frame->channel!=3?1:0};

char *data=ResizeData(new_size);

XImage

*image=XCreateImage(dpy,global->visinfo->visual,depth,ZPixmap,0,data,img_size[0],i

mg_size[1],8,bpl);

Pixmap

pixmap=XCreatePixmap(dpy,DefaultRootWindow(dpy),img_size[0],img_size[1],depth);

Dprintf("UpdateImage\n");

if (global->levels==2 && frame->channel==3) frame->channel=0;

for(y=0;y<size[1];y++) for(x=0;x<size[0];x++) {

int data_x=x, data_y=y, off_x, off_y, oct;

if (vid->trans.type==TRANS_Wave)

CvtIndex(x,y,size[0],size[1],space,&data_x,&data_y,&oct);

for(off_x=0;off_x<1<<frame->zoom;off_x++)

for(off_y=0;off_y<1<<frame->zoom;off_y++) {

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```

        int    img_x=off_x+(x < < frame-> zoom),
img_y=off_y+(y < < frame-> zoom),

pix=CompositePixel(frame,data_x,data_y,img_x,img_y);

XPutPixel(image,img_x,img_y,ReMap(pix,global->levels,pal));
    }
}

XPutImage(dpy,pixmap,DefaultGC(dpy,scrn),image,0,0,0,0,img_size[0],img_size[1]);
    if (frame->point_switch == True) UpdatePoint(dpy,frame,pixmap);
    XtFree(image);
    return(pixmap);
}

void  CvtIndex(x,y,max_x,max_y,oct,ret_x,ret_y,ret_oct)

int    x, y, max_x, max_y, oct, *ret_x, *ret_y, *ret_oct;

{
    Boolean    hgx=x>=(max_x>>1), hgy=y>=(max_y>>1);

    *ret_x=hgx?x-(max_x>>1):x;
    *ret_y=hgy?y-(max_y>>1):y;
    if (!hgx && !hgy && oct>1) {

CvtIndex(*ret_x,*ret_y,max_x>>1,max_y>>1,oct-1,ret_x,ret_y,ret_oct);

        *ret_x= *ret_x<<1;
        *ret_y= *ret_y<<1;
        *ret_oct+=1;
    } else {

```


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```

*ret_x = (*ret_x < 1) + hgx;
*ret_y = (*ret_y < 1) + hgy;
*ret_oct = hgx || hgy ? 0 : 1;

```

```

void UpdateInfo(frame)

```

```

Frame frame;

```

```

{
    Message    msg = frame->msg;
    Video  vid = frame->video;
    int      *locn = frame->point->location, posn[2] = {locn[0], locn[1]},
            channel = 3 == frame->channel ? 0 : frame->channel,
width = Size(vid, channel, 0);
    short  *data = vid->data[channel][frame->frame];

    msg->info.ptr[0] = '\0';
    msg->info.length = 0;
    if (vid->type == YUV && channel != 0) {
        posn[0] = posn[0] >> vid->UVsample[0];
        posn[1] = posn[1] >> vid->UVsample[1];
    }
    if (vid->trans.type != TRANS_Wave)
        Mprintf(msg, "Point : x = %03d y = %03d t = %03d
c = %4d", locn[0], locn[1], frame->frame + vid->start, data[posn[0] + Size(vid, channel, 0) * po
sn[1]]);
    else {
        int      octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0],

```

```

X, Y, oct, sub,

```

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```
blkDC[2] = {(posn[0] > > octs) & -2, (posn[1] > > octs) & -2},
```

```
offDC[2] = {(posn[0] > > octs) & 1, (posn[1] > > octs) & 1};
```

```
Mprintf(msg, "Point : f= %03d x= %03d
```

```
y= %03d\n", frame->frame + vid->start, locn[0], locn[1]);
```

```
Mprintf(msg, "Low pass: x= %03d y= %03d\n", blkDC[0], blkDC[1]);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(X=0; X<2; X++)
```

```
Mprintf(msg, "%4d%c", data[Access(blkDC[0]+X, blkDC[1]+Y, octs-1, 0, width)], X == off
DC[0] && Y == offDC[1]? '*' : ' ');
```

```
    Mprintf(msg, "\n");
```

```
}
```

```
for(oct=octs; oct>0; oct--) {
```

```
    int blk[2] = {(posn[0] > > oct) & -2, (posn[1] > > oct) & -2},
```

```
    off[2] = {(posn[0] > > oct) & 1, (posn[1] > > oct) & 1};
```

```
Mprintf(msg, "Oct : %d\n", oct);
```

```
for(Y=0; Y<2; Y++) {
```

```
    for(sub=1; sub<4; sub++) {
```

```
        for(X=0; X<2; X++) {
```

```
Mprintf(msg, "%4d%c", data[Access(blk[0]+X, blk[1]+Y, oct-1, sub, width)], X == off[0]
&& Y == off[1]? '*' : ' ');
```

```
        }
```

```
        if (sub < 3) Mprintf(msg, " ");
```

```
    }
```

```
    if (oct != 0 || Y == 0) Mprintf(msg, "\n");
```

```
}
```

```
}
```

```
}
```

```
Mflush(msg);
```

```
}
```

```
/*  Function Name:    CrossHair.
 *  Description:    Draws cross-hair on pixmap
 *  Arguments:    dpy - Xserver display
 *
 *                pixmap - pixmap to draw on
 *                gc - GC to draw with
 *                x_off, y_off - offset into pixmap
 *                width, height - size of box containing cross-hair
 *                x, y - coordinates within box
 *                zoom - scaling factor
 *
 *  Returns:    alters pixmap.
 */
```

```
void  CrossHair(dpy,pixmap,gc,x_off,y_off,width,height,x,y,zoom)
```

```
Display    *dpy;
```

```
Pixmap    pixmap;
```

```
GC         gc;
```

```
int    x_off, y_off, width, height, x, y, zoom;
```

```
{
```

```
    int    xtra=Shift(1,zoom);
```

```
    x_off=Shift(x_off,zoom);
```

```
    y_off=Shift(y_off,zoom);
```

```
    width=Shift(width,zoom);
```

```
    height=Shift(height,zoom);
```

```
    x=Shift(x,zoom);
```

```
    y=Shift(y,zoom);
```

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```

XFillRectangle(dpy,pixmap,gc,x+x_off+xtra/2,y_off,1,y); /* North hair */
XFillRectangle(dpy,pixmap,gc,x_off,y+y_off+xtra/2,x,1); /* West hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+xtra/2,y+y_off+xtra,1,height-y-xtra); /*
South hair */
XFillRectangle(dpy,pixmap,gc,x+x_off+xtra,y+y_off+xtra/2,width-x-1,1); /*
East hair */
}

```

```

/*  Function Name:    UpdatePoint
*   Description:    Draws cross-hair on image at frame->location
*   Arguments:    dpy - X server display
*                  frame - Frame supplying drawing parameters
*                  pixmap - X pixmap to draw on
*   Returns:      alters pixmap.
*/

```

```
void  UpdatePoint(dpy,frame,pixmap)
```

```
Display    *dpy;
```

```
Frame frame;
```

```
Pixmap    pixmap;
```

```

{
    unsigned long    gcmask;
    XGCValues    gcvals;
    GC    gc;
    Video    vid=frame->video;
    int    posn[2]={frame->point->location[0],frame->point->location[1]},
    channel=3==frame->channel?0:frame->channel;

```

```
    gcvals.function=GXequiv;
```

```
    gcmask=GCFFunction;
```

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```

gcvals.foreground = 127;
gcmask = gcmask | GCForeground;
gc = XCreateGC(dpy, pixmap, gcmask, &gcvals);
if (vid->type == YUV && channel != 0) {
    posn[0] = posn[0] >> vid->UVsample[0];
    posn[1] = posn[1] >> vid->UVsample[1];
}
if (vid->trans.type != TRANS_Wave) {

CrossHair(dpy, pixmap, gc, 0, 0, Size(vid, channel, 0), Size(vid, channel, 1), posn[0], posn[1], fra
me->zoom);
    } else {
        int    octs = vid->trans.wavelet.space[vid->type == YUV &&
channel != 0 ? 1 : 0], oct,
                size[2] = {Size(vid, channel, 0), Size(vid, channel, 1)};

CrossHair(dpy, pixmap, gc, 0, 0, size[0], size[1], posn[0], posn[1], frame->zoom-octs);
        for(oct = 1; oct <= octs; oct++) {

CrossHair(dpy, pixmap, gc, size[0], 0, size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, 0, size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct);

CrossHair(dpy, pixmap, gc, size[0], size[1], size[0], size[1], posn[0], posn[1], frame->zoom-oct
);
        }
    }
XFreeGC(dpy, gc);
}

```

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source/Video2.c

```
/*
    Video callback routines for Listing, Loading
*/

#include    "../include/xwave.h"
#include    "../include/ImageHeader.h"
#include    "../include/DTheader.h"
#include    "Video.h"
#include    <sys/time.h>

extern void EraseFrame();
extern void CvtIndex();

void SortList(list,no)

String list[];
int no;

{
    int i, j, k;

    if (no > 1) for(i=1; i < no; i++) for(j=0; j < i; j++) {
        k=0;
        while(list[i][k] == list[j][k] && list[i][k] != '\0' && list[j][k] != '\0') k++;
        if (list[i][k] < list[j][k]) {
            String spare=list[i];

            list[i]=list[j];
            list[j]=spare;
        }
    }
}
```

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```

    }
}

String *ReadDirectory(dir_path,extension)

```

```

String dir_path, extension;

```

```

{
    DIR    *dirp, *opendir();
    struct dirent *dp, *readdir();
    static String *fileList=NULL, file;
    int     count=0, i;
    char    path[STRLEN];

    Dprintf("ReadDirectory for %s extension\n",extension);
    if (fileList!=NULL) {
        for(i=0;NULL!=fileList[i];i++) free(fileList[i]);
        free(fileList);
    }
    fileList=(String *)MALLOC(sizeof(String *)*300);
    sprintf(path,"%s%s\0",global->home,dir_path);
    dirp=opendir(path);
    for (dp=readdir(dirp);dp!=NULL && count<299;dp=readdir(dirp)) {
        int     length=strlen(dp->d_name);

        if (length>=strlen(extension))
            if (!strcmp(dp->d_name+length-strlen(extension),extension)) {
                Dprintf("Found %s in dir\n",dp->d_name);
                fileList[count]=(char *)MALLOC(length+1);
                strncpy(fileList[count],dp->d_name,length-strlen(extension));
                count+=1;
            }
    }
}

```

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```

    }
    fileList[count]=NULL;
    SortList(fileList,count);
    closedir(dirp);
    return(fileList);
}

```

```

int  Shift(value,shift)

```

```

int  value, shift;

```

```

{
    if (shift==0) return value;
    else if (shift<0) return(value >> -shift);
    else return(value << shift);
}

```

```

int  Size(video,channel,dimension)

```

```

Video video;

```

```

int  channel, dimension;

```

```

{
    if (video->type==YUV && dimension!=2 && channel!=0 && channel!=3)
return(video->size[dimension]>> video->UVsample[dimension]);
    else return(video->size[dimension]);
}

```

```

int  Address2(video,channel,x,y)

```

```

Video video;

```

```

int  channel, x, y;

```


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```

{
    if (video->type == YUV && channel!=0 && channel!=3)
return(x + Size(video,channel,0)*y);
    else return(x + video->size[0]*y);
}

int    Address(video,channel,x,y)

Video video;
int    channel, x, y;

{
    if (video->type == YUV && channel!=0 && channel!=3)
return((x >> video->UVsample[0]) + Size(video,channel,0)*(y >> video->UVsample[1])
);
    else return(x + video->size[0]*y);
}

String *VideoList()

{
    Dprintf("VideoList\n");
    return(ReadDirectory(VID_DIR,VID_EXT));
}

String *KlicsList()

{
    Dprintf("KlicsList\n");
    return(ReadDirectory(KLICS_DIR,KLICS_EXT));
}

```

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String *KlicsListSA()

```
{  
    Dprintf("KlicsListSA\n");  
    return(ReadDirectory(KLICS_SA_DIR,KLICS_SA_EXT));  
}
```

String *VideoCurrentList()

```
{  
    static String videoList[300];  
    Video video=global->videos;  
    int count=0;  
  
    Dprintf("VideoCurrentList\n");  
    while (video!=NULL) {  
        if (count==300) Dprintf("VideoCurrentList: static size exceeded\n");  
        videoList[count]=video->name;  
        video=video->next;  
        count+=1;  
    }  
    videoList[count]=NULL;  
    SortList(videoList,count);  
    return(videoList);  
}
```

String *VideoYUVList()

```
{  
    static String videoList[300];  
    Video video=global->videos;  
    int count=0;
```

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```

Dprintf("VideoCurrentList\n");
while (video!=NULL) {
    if (count==300) Dprintf("VideoYUVList: static size exceeded\n");
    if (video->type==YUV) videoList[count++] = video->name;
    video=video->next;
}
videoList[count]=NULL;
SortList(videoList,count);
return(videoList);
}

```

```
String *VideoDropList()
```

```

{
    static String videoList[300];
    Video video=global->videos;
    int count=0;
    Boolean VideoHasFrame();

    Dprintf("VideoDropList\n");
    while (video!=NULL) {
        if (False==VideoHasFrame(video,global->frames)) {
            videoList[count]=video->name;
            count+=1;
        };
        video=video->next;
    }
    videoList[count]=NULL;
    SortList(videoList,count);
    return(videoList);
}

```

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Boolean VideoHasFrame(video,frame)

Video video;

Frame frame;

```
{
    if (frame == NULL) return(False);
    else if (frame->video == video) return(True);
        else return(VideoHasFrame(video,frame->next));
}
```

void VideoLoad(w,closure,call_data)

Widget w;

caddr_t closure, call_data;

```
{
    Video vid=(Video)MALLOC(sizeof(VideoRec));
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
    int    frame, channel;

    Dprintf("VideoLoad %s\n",name->string);
    strcpy(vid->name,name->string);
    strcpy(vid->files,name->string);
    vid->next=global->videos;
    global->videos=vid;
    vid->rate=30;
    Parse(VID_DIR,name->string,VID_EXT);
    for (channel=0;channel < (vid->type == MONO?1:3);channel++)
        vid->data[channel]=(short **)MALLOC(sizeof(short *)*vid->size[2]);
    if (!vid->disk) for(frame=0;frame < vid->size[2];frame++)
        GetFrame(vid,frame);
}
```

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```
Dprintf("VideoLoad terminated\n");
```

```
if (global->batch == NULL) InitFrame(w,closure,call_data);
```

```
}
```

```
void VideoSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
Video video;
```

```
XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
int frame;
```

```
video=FindVideo(name->string,global->videos);
```

```
if (video->files[0] == '\0') strcpy(video->files,name->string);
```

```
SaveHeader(video);
```

```
for (frame=0;frame < video->size[2];frame++) {
```

```
    Boolean disk=video->disk;
```

```
    GetFrame(video,frame);
```

```
    video->disk=True;
```

```
    SaveFrame(video,frame);
```

```
    video->disk=disk;
```

```
    FreeFrame(video,frame);
```

```
}
```

```
Dprintf("VideoSave terminated\n");
```

```
}
```

```
void VideoDTSave(w,closure,call_data)
```

```
Widget      w;
```

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```
caddr_t closure, call_data;
```

```
{
```

```
Video video;
```

```
FILE *fp, *fopen();
```

```
XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
char file_name[STRLEN], whole_frame[512][512];
```

```
int frame, i, x, y, offset[2];
```

```
DTheader
```

```
header={"DT-IMAGE",1,4,1,2,"",1,{0,0,4,0},1,1,0,1,{4,3},8,1,{0,2},{0,2},{0,2},{0,2},"", "xwave generated image", ""};
```

```
Dprintf("VideoDTSave %s\n",name->string);
```

```
video=FindVideo(name->string,global->videos);
```

```
sprintf(file_name,"%s%s/%s/%s%s",global->home,IMAGE_DIR,video->path,video->files,".img");
```

```
offset[0]=(512-video->size[0])/2;
```

```
offset[1]=(512-video->size[1])/2;
```

```
offset[0]=offset[0]<0?0:offset[0];
```

```
offset[1]=offset[1]<0?0:offset[1];
```

```
fp=fopen(file_name,"w");
```

```
fwrite(&header,1,sizeof(DTheader),fp);
```

```
GetFrame(video,0);
```

```
for(y=0;y<512;y++) for(x=0;x<512;x++) {
```

```
    int X, Y, oct;
```

```
    if (y<offset[1] || x<offset[0] || y-offset[1]>=video->size[1] ||
```

```
x-offset[0]>=video->size[0]) whole_frame[y][x]=0;
```

```
    else {
```

```
        if (video->trans.type==TRANS_Wave) {
```

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```
CvtIndex(x-offset[0],y-offset[1],video->size[0],video->size[1],video->trans.wavelet.space[0],&X,&Y,&oct);
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X]*(oct==video->trans.wavelet.space[0]?1:4),video->precision);
```

```
    } else {
```

```
        X=x-offset[0]; Y=y-offset[1];
```

```
whole_frame[y][x]=128+Round(video->data[0][0][Y*video->size[0]+X],video->precision);
```

```
    }
```

```
}
```

```
}
```

```
FreeFrame(video,0);
```

```
fwrite(whole_frame,1,512*512,fp);
```

```
fclose(fp);
```

```
}
```

```
void VideoXimSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    Video video;
```

```
    FILE *fp, *fopen();
```

```
    XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
    char file_name[STRLEN], *whole_frame;
```

```
    int frame, channel, i, x, y;
```

```
    ImageHeader header;
```

```
Dprintf("VideoXimSave %s\n",name->string);
```

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```

video = FindVideo(name -> string, global -> videos);
whole_frame = (char *) MALLOC(video -> size[0] * video -> size[1]);
if (video -> files[0] == '\0') strcpy(video -> files, name -> string);

sprintf(file_name, "%s%s/%s/%s%s\0", global -> home, IMAGE_DIR, video -> path, video -
> files, ".xim");
fp = fopen(file_name, "w");
sprintf(header.file_version, "%8d", IMAGE_VERSION);
sprintf(header.header_size, "%8d", 1024);
sprintf(header.image_width, "%8d", video -> size[0]);
sprintf(header.image_height, "%8d", video -> size[1]);
sprintf(header.num_colors, "%8d", 256);
sprintf(header.num_channels, "%8d", video -> type == MONO ? 1 : 3);
sprintf(header.num_pictures, "%8d", video -> size[2]);
sprintf(header.alpha_channel, "%4d", 0);
sprintf(header.runlength, "%4d", 0);
sprintf(header.author, "%48s", "xwave");
sprintf(header.date, "%32s", "Now");
sprintf(header.program, "%16s", "xwave");
for(i=0; i < 256; i++) {
    header.c_map[i][0] = (unsigned char)i;
    header.c_map[i][1] = (unsigned char)i;
    header.c_map[i][2] = (unsigned char)i;
}
fwrite(&header, 1, sizeof(ImageHeader), fp);
for (frame = video -> start; frame < video -> start + video -> size[2]; frame++) {
    GetFrame(video, frame - video -> start);
    for(channel = 0; channel < (video -> type == MONO ? 1 : 3); channel++) {
        for(x = 0; x < video -> size[0]; x++)
            for(y = 0; y < video -> size[1]; y++)
                whole_frame[x + video -> size[0] * y] = itc(video -> data[channel][frame - video -> start][Addr

```


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```

ss(video.channel,x,y)] > > video->precision);
        fwrite(whole_frame,sizeof(char),video->size[0]*video->size[1],fp);
    }
    FreeFrame(video.frame-video->start);
}
fclose(fp);
XtFree(whole_frame);
}

```

```

void VideoMacSave(w,closure,call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{

```

```

    Video video;

```

```

    FILE *fp, *fopen();

```

```

    XawListReturnStruct *name=(XawListReturnStruct *)call_data;

```

```

    char file_name[STRLEN], *whole_frame;

```

```

    int frame, channel, i, x, y;

```

```

    Dprintf("VideoMacSave %s\n",name->string);

```

```

    video=FindVideo(name->string,global->videos);

```

```

    if (video->files[0] == '\0') strcpy(video->files,name->string);

```

```

    sprintf(file_name,"%s%s/%s/%s%s\0",global->home,IMAGE_DIR,video->path,video-
    >files,".mac");

```

```

    fp=fopen(file_name,"w");

```

```

    whole_frame=(char *)MALLOC(video->size[1]*video->size[0]*3);

```

```

    for(frame=0;frame<video->size[2];frame++) {

```

```

        int size=video->size[0]*video->size[1];

```

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```

    GetFrame(video, frame);
    for(channel=0; channel < (video->type == MONO?1:3); channel++)
        for(x=0; x < video->size[0]; x++)
            for(y=0; y < video->size[1]; y++)

        whole_frame[(x+video->size[0]*y)*3+channel]=itc(video->data[channel][frame][Address(
video.channel,x,y)] >> video->precision);
        fwrite(whole_frame, 1, 3*size, fp);
        FreeFrame(video, frame);
    }
    fclose(fp);
    XtFree(whole_frame);
}

```

```

void VideoHexSave(w, closure, call_data)

```

```

Widget      w;

```

```

caddr_t      closure, call_data;

```

```

{

```

```

    Video video;

```

```

    FILE *fp, *fopen();

```

```

    XawListReturnStruct *name=(XawListReturnStruct *)call_data;

```

```

    char file_name[STRLEN];

```

```

    int frame, channel, i;

```

```

    Dprintf("VideoHexSave %s\n", name->string);

```

```

    video=FindVideo(name->string, global->videos);

```

```

    if (video->files[0] == '\0') strcpy(video->files, name->string);

```

```

    sprintf(file_name, "%s%s/%s/%s%s\0", global->home, IMAGE_DIR, video->path, video->files, ".h");

```

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```

fp=fopen(file_name,"w");
for(frame=0;frame<(video->size[2]>2?2:video->size[2]);frame++) {
    int    size=video->size[1]*video->size[0];

    GetFrame(video,frame);

    fprintf(fp,"char
%s%d[%d]={\n",name->string[strlen(name->string)-1]=='d'? "src": "dst".frame.size);
    for(i=0;i<size;i++)

fprintf(fp,"0x%02x,%c",(video->data[0][frame][i]>>video->precision)+128,i%20==
19?'\\n':' ');

    fprintf(fp,"\\n};\\n");
    FreeFrame(video,frame);
}
fclose(fp);
}

```

```
#define AB_WIDTH 1440
```

```
#define AB_HEIGHT 486
```

```
void VideoAbekusSave(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```

{
    AbekusCtrl ctrl=(AbekusCtrl)closure;
    FILE *fp,*fopen();
    char file_name[STRLEN], *data=(char
*)MALLOC(AB_WIDTH*AB_HEIGHT), zero=itc(0);
    int frame, channel, i, x, y, length=0;
    Video vids[4];

```

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```

Dprintf("VideoAbekusSave\n");
for(i=0;i<4;i++)
    if (ctrl->names[i]!=NULL) {
        vids[i]=FindVideo(ctrl->names[i],global->videos);
        length=length>vids[i]->size[2]?length:vids[i]->size[2];
    } else vids[i]=NULL;
for(frame=0;frame<length;frame++) {
    sprintf(file_name,"%d.yuv\0",frame+1);
    fp=fopen(file_name,"w");
    for(i=0;i<4;i++) GetFrame(vids[i],frame);
    for(y=0;y<AB_HEIGHT;y++)
        for(x=0;x<AB_WIDTH;x++) {
            int
i=(x<AB_WIDTH/2?0:1)+(y<AB_HEIGHT/2?0:2),
            Y=y<AB_HEIGHT/2?y:y-AB_HEIGHT/2,
            X=(x<AB_WIDTH/2?x:x-AB_WIDTH/2)/2,
            channel=((x&1)==1)?0:((X&1)==0)?1:2;

            if (vids[i]->type==MONO && channel!=0 ||
X>=vids[i]->size[0] || Y>=vids[i]->size[1]) data[x+y*AB_WIDTH]=zero;
            else
data[x+y*AB_WIDTH]=itc(vids[i]->data[channel][frame][Address(vids[i],channel,X,Y)]
>>vids[i]->precision);
        }
    for(i=0;i<4;i++) {
        FreeFrame(vids[i],frame);
        EraseFrame(vids[i],frame);
    }
    fwrite(data,1,AB_WIDTH*AB_HEIGHT,fp);
    fclose(fp);
}
}

```

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```
void VideoDrop(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
Video *videos=&global-> videos, video;
```

```
XawListReturnStruct *name=(XawListReturnStruct *)call_data;
```

```
int channel, frame;
```

```
Dprintf("VideoDrop %s\n",name-> string);
```

```
video=FindVideo(name-> string,global-> videos);
```

```
while (*videos!=video && *videos!=NULL) videos=&((*videos)-> next);
```

```
if (*videos!=NULL) {
```

```
    *videos=(*videos)-> next;
```

```
    for(channel=0;channel<(video-> type == MONO?1:3);channel++)
```

```
        if (video-> data[channel]!=NULL) {
```

```
            for(frame=0;frame< video-> size[2];frame++)
```

```
                if (video-> data[channel][frame]!=NULL)
```

```
                    XtFree(video-> data[channel][frame]);
```

```
                    XtFree(video-> data[channel]);
```

```
        }
```

```
    XtFree(video);
```

```
}
```

```
}
```

```
/* Obsolete
```

```
void VideoDiff(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

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```

XawListReturnStruct *name=(XawListReturnStruct *)call_data;
Video src=FindVideo(name->string,global->videos), dst=CopyHeader(src);
int frame, channel, i;

printf("VideoDiff %s\n",name->string);
sprintf(dst->name,"%s.dif\0",src->name);
for(frame=0;frame<src->size[2];frame++) {
    GetFrame(src,frame);
    NewFrame(dst,frame);
    for(channel=0;channel<(video->type==MONO?1:3);channel++)
        for(i=0;i<src->size[1]*src->size[0];i++)

dst->data[channel][frame][i]=src->data[channel][frame][i]-(frame==0?0:src->data[channel][frame-1][i]);

    SaveFrame(dst,frame);
    FreeFrame(dst,frame);
    if (frame>0) FreeFrame(src,frame-1);
}
FreeFrame(dst,src->size[2]-1);
dst->next=global->videos;
global->videos=dst;
}
*/
void VideoClean(w,closure,call_data)

Widget w;
caddr_t closure, call_data;

{
    Video *videos=&global->videos, video;
    int channel, frame;

```

```

Dprintf("VideoClean\n");
while(*videos!=NULL) {
    video=*videos;
    if (False == VideoHasFrame(video,global->frames)) {
        Dprintf("Erasing video: %s\n",video->name);

for(channel=0;channel < (video->type == MONO?1:3);channel++)
        if (video->data[channel]!=NULL) {
            for(frame=0;frame < video->size[2];frame++)
                if (video->data[channel][frame]!=NULL)
XtFree(video->data[channel][frame]);
            XtFree(video->data[channel]);
        }
        *videos=video->next;
        XtFree(video);
    } else videos=&(*videos)->next;
}
}

```

```

typedef struct {
    Frame frame;
    XtIntervalId id;
    unsigned long interval;
    long msec, shown, average;
    Pixmap *movie;
    int fno, old_fno;
} MovieArgRec, *MovieArg;

```

```

void Projector(client_data,id)

```

```

XtPointer client_data;
XtIntervalId *id;

```

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```

{
    MovieArg    movieArg=(MovieArg)client_data;
    Display      *dpy=XtDisplay(global->toplevel);
    struct timeval    tp;
    struct timezone    tzp;
    long    new_msec;
    int    scrn=XDefaultScreen(dpy);

movieArg->id=XtAppAddTimeOut(global->app_con,movieArg->interval,Projector,mo
vieArg);

    gettimeofday(&tp,&tzp);
    new_msec=tp.tv_sec*1000+tp.tv_usec/1000;
    if (movieArg->msec!=0) {

movieArg->average=(movieArg->average*movieArg->shown+new_msec-movieArg-
>msec)/(movieArg->shown+1);
        movieArg->shown++;
    }
    movieArg->msec=new_msec;

XCopyArea(dpy,movieArg->movie[movieArg->fno],XtWindow(movieArg->frame->i
mage_widget),DefaultGC(dpy,scrn),0,0,movieArg->frame->video->size[0],movieArg-
>frame->video->size[1],0,0);

movieArg->fno=movieArg->fno==movieArg->frame->video->size[2]-1?0:movieAr
g->fno+1;
}

void    StopMovie(w,closure,call_data)

Widget    w;

```


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```
caddr_t      closure, call_data;
```

```
{
    MovieArg  movieArg=(MovieArg)closure;
    Display   *dpy=XtDisplay(global->toplevel);
    int       i;
    Arg       args[1];

    XtRemoveTimeout(movieArg->id);
    Dprintf("Movie showed %d frames at an average of %f
    fps\n",movieArg->shown,1000.0/(float)movieArg->average);
    for(i=0;i<movieArg->frame->video->size[2];i++)
    XFreePixmap(dpy,movieArg->movie[i]);
    XtFree(movieArg->movie);
    XtSetArg(args[0],XtNbitmap,UpdateImage(movieArg->frame));
    XtSetValues(movieArg->frame->image_widget,args,ONE);
    XSynchronize(dpy,False);
}
```

```
#define      MOVIE_ICONS      1
```

```
void  Movie(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t      closure, call_data;
```

```
{
    Video video=((Frame)closure)->video;
    MovieArg  movieArg=(MovieArg)MALLOC(sizeof(MovieArgRec));
    Widget    shell=ShellWidget("movie",XtParent(w),SW_over,NULL,NULL),
    form=FormatWidget("movie_form",shell),
    widgets[MOVIE_ICONS];
```

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```

Display      *dpy=XtDisplay(global->toplevel);
FormItem     items[]={
    {"movie_stop","stop",0,0,FW_icon,NULL},
};
XtCallbackRec callbacks[]={
    {StopMovie,(caddr_t)movieArg},
    {Free,(caddr_t)movieArg},
    {Destroy,(caddr_t)shell},
    {NULL,NULL},
};
int          i;
XGCValues    values;
GC           gc;

Dprintf("Movie\n");

FillForm(form,MOVIE_ICONS,items,widgets,callbacks);
XtPopup(shell,XtGrabExclusive);

values.foreground=255;
values.background=0;
gc=XtGetGC(XtParent(w),GCForeground | GCBackground,&values);
movieArg->frame=(Frame)closure;
movieArg->movie=(Pixmap *)MALLOC(video->size[2]*sizeof(Pixmap));
movieArg->old_fno=movieArg->frame->frame;
for(i=0;i<video->size[2];i++) {
    char fno[STRLEN];

    sprintf(fno,"%03d\0",i+video->start);
    movieArg->frame->frame=i;
    GetFrame(video,i);
    movieArg->movie[i]=UpdateImage(movieArg->frame);
}

```

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```
XDrawImageString(dpy, movieArg->movie[i], gc, video->size[0]-50, 10, fno, 3);
```

```
XCopyArea(dpy, movieArg->movie[i], XtWindow(movieArg->frame->image_widget), D
efaultGC(dpy, 0), 0, 0, video->size[0], video->size[1], 0, 0);
```

```
    movieArg->frame->frame = movieArg->old_fno;
```

```
    FreeFrame(video, i);
```

```
}
```

```
XtDestroyGC(gc);
```

```
movieArg->fno = 0;
```

```
movieArg->msec = 0;
```

```
movieArg->shown = 0;
```

```
movieArg->average = 0;
```

```
movieArg->interval = 1000/video->rate;
```

```
movieArg->id = XtAppAddTimeOut(global->app_con, movieArg->interval, Projector, mo
vieArg);
```

```
    XSynchronize(dpy, True);
```

```
}
```

```
void Compare(w, closure, call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
    XawListReturnStruct *name = (XawListReturnStruct *)call_data;
```

```
    Video src = (Video)closure, dst = FindVideo(name->string, global->videos);
```

```
    int channels = src->type == MONO || dst->type == MONO ? 1:3, channel,
```

```
    values = 0, x, y,
```

```
    frames = src->size[2] > dst->size[2] ? dst->size[2]:src->size[2],
```

```
    frame;
```

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```

double      mse;
Message      msg=NewMessage(NULL,400);
XtCallbackRec  callbacks[]={
    {CloseMessage,(caddr_t)msg}, {NULL,NULL},
};

msg->rows=frames>5?10:2*frames; msg->cols=40;
if (global->batch==NULL)
MessageWindow(FindWidget("frm_compare",w),msg,"Compare",True,callbacks);
for(frame=0;frame<frames;frame++) {
    Boolean      srcp=src->precision>dst->precision;
    int      err_sqr=0,
precision=srcp?src->precision-dst->precision:dst->precision-src->precision;

    Mprintf(msg,"Compare: %s%03d and
%s%03d\n",src->name,src->start+frame,dst->name,dst->start+frame);
    GetFrame(src,frame);
    GetFrame(dst,frame);
    for(channel=0;channel<channels;channel++) {

values+=Size(src->size[1]>dst->size[1]?dst:src,channel,1)*Size(src->size[0]>dst->size[0]?dst:src,channel,0);

for(y=0;y<Size(src->size[1]>dst->size[1]?dst:src,channel,1);y++)

for(x=0;x<Size(src->size[0]>dst->size[0]?dst:src,channel,0);x++) {
        int
err=(src->data[channel][frame][x+Size(src,channel,0)*y]<<(srcp?0:precision))-(dst->data[channel][frame][x+Size(dst,channel,0)*y]<<(srcp?precision:0));

        err_sqr+=err*err;
    }
}

```

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```

    }
    FreeFrame(src.frame);
    FreeFrame(dst.frame);
    mse=(double)err_sqr/(double)(values);
    Mprintf(msg,"Error %d MSE %f PSNR
%f\n",err_sqr,mse,10*log10(pow((pow(2.0,(double)(8+(srcp?src->precision:dst->precis
ion)))-1),2.0)/mse));
    Mflush(msg);
}
}

```

```
void BatchCompare(w,closure,call_data)
```

```
Widget      w;
```

```
caddr_t     closure, call_data;
```

```
{
```

```
String name=(String)closure;
```

```
closure=(caddr_t)FindVideo(name,global->videos);
```

```
Compare(w,closure,call_data);
```

```
}
```

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source/xwave.c

```
#include    "../include/xwave.h"
#include    <X11/Xresource.h>
#include    <X11/Intrinsic.h>
#include    <X11/Quarks.h>
```

```
extern Palette      ReOrderPalettes();
extern void  NameButton();
extern void  ImageNotify();
extern void  Parse();
```

```
#define    IconPath      "bitmaps"
#define    IconFile      "xwave.icons"
#define    CompressPath  "."
#define    CompressExt   ".compress"
#define    PalettePath   "."
#define    PaletteExt    ".pal"
```

```
Global      global;
```

```
String ChannelName[3][4]={
    {"GreyScale",NULL,NULL,NULL},
    {"Red  ", "Green", "Blue ", "Color"},
    {"Y-Lumunance", "U-Chrome  ", "V-Chrome  ", "Color  "},
};
```

```
#define    XtNdebug "debug"
#define    XtNbatch "batch"
```

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```
static XtResource resources[] = {
    {XtNdebug, XtCBoolean, XtRBoolean, sizeof(Boolean),
     XtOffset(Global,debug), XtRString, "false"},
    {XtNbatch, XtCFile, XtRString, sizeof(String),
     XtOffset(Global,batch), XtRString, NULL},
};
```

```
static XrmOptionDescRec options[]={
    {"-debug","*debug",XrmoptionNoArg,"true"},
    {"-batch","*batch",XrmoptionSepArg,NULL},
};
```

```
static Boolean CvtStringToPixel2();
```

```
#if defined(__STDC__)
externref XtConvertArgRec const colorConvertArgs[2];
#else
externref XtConvertArgRec colorConvertArgs[2];
#endif
```

```
static String fallback_resources[]={
    "**copy_video*Toggle*translations: #override \\n <Btn1Down>,<Btn1Up>:
set() notify()",
    "**copy_video*copy*state: true",
    NULL,
};
```

```
XtActionsRec actionTable[]={
    {"NameButton",NameButton},
};
```

```
main(argc,argv,envp)
```

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```

int    argc;
char   *argv[], *envp[];

{
    void    InitPixmaps(), InitActions(), InitMain(), InitEnv(), InitDither(), Dispatch();
    GlobalRec    globalrec;

    global=&globalrec;
    global->videos=NULL;
    global->frames=NULL;
    global->points=NULL;
    InitEnv(envp);

    global->toplevel=XtAppInitialize(&(global->app_con),"xwave",options,XtNumber(options),
    &argc,argv,fallback_resources,NULL,ZERO);

    XtGetApplicationResources(global->toplevel,global,resources,XtNumber(resources),NULL,
    ZERO);
    if (global->batch!=NULL) {
        Parse(BATCH_DIR,global->batch,BATCH_EXT);
        if (global->batch_list!=NULL) Dispatch(global->batch_list);
    }
    if (global->batch==NULL) {
        XtAppAddActions(global->app_con,actionTable,XtNumber(actionTable));

    XtSetTypeConverter(XtRString,XtRPixel,CvtStringToPixel2,colorConvertArgs,XtNumber
    (colorConvertArgs),XtCacheByDisplay,NULL);

        if (global->debug) Dprintf("Xwave Debugging Output\n");
        InitVisual();
        InitDither();
        InitPixmaps(IconPath,IconFile);
        Parse(PalettePath,"xwave",PaletteExt);

```


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```

    global->palettes = ReOrderPalettes(global->palettes, global->palettes);
    InitActions(global->app_con);
    InitMain();
    XtRealizeWidget(global->toplevel);
    XtAppMainLoop(global->app_con);
}
}

```

```
void InitEnv(envp)
```

```
char *envp[];
```

```

{
    String home=NULL, xwave=NULL;

    Dprintf("Initializing enviroment\n");
    while(*envp!=NULL) {
        if(!strcmp(*envp, "HOME=", 5)) home = (*envp) + 5;
        if(!strcmp(*envp, "XWAVE=", 6)) xwave = (*envp) + 6;
        envp++;
    }
    if (xwave!=NULL) sprintf(global->home, "%s/", xwave);
    else sprintf(global->home, "%s/xwave/", home);
}

```

```
#define HEIGHT 14
```

```
void InitPixmap(path, file)
```

```
char *file, *path;
```

```
{
```

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```

FILE *fp, *fopen();

Icon icons;

char pad[100];

Display *dpy = XtDisplay(global->toplevel);

int i, j, sink, scrn = XDefaultScreen(dpy), depth = DisplayPlanes(dpy, scrn),
    bpl = (global->levels*depth+7)/8;

char data[HEIGHT*bpl];

XImage
*image = XCreateImage(dpy, global->visinfo->visual, depth, ZPixmap, 0, data, global->levels, HEIGHT, 8, bpl);

sprintf(pad, "%s%s/ %s\0", global->home, path, file);
if (NULL == (fp=fopen(pad, "r"))) {
    Eprintf("Can't open file %s\n", pad);
    exit();
}

fscanf(fp, "%d\n", &global->no_icons);
global->icons = (Icon)MALLOC((1+global->no_icons)*sizeof(IconRec));
for(i=0; i<global->no_icons; i++) {
    global->icons[i].name = (String)MALLOC(100);
    fscanf(fp, "%s\n", global->icons[i].name);
    sprintf(pad, "%s%s/ %s\0", global->home, path, global->icons[i].name);
    XReadBitmapFile(
        XtDisplay(global->toplevel),
        XDefaultRootWindow(dpy),
        pad,
        &global->icons[i].width,
        &global->icons[i].height,
        &global->icons[i].pixmap,
        &sink,
        &sink
    );
}

```

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```

    }
    global->icons[global->no_icons].name=(String)MALLOC(100);
    strcpy(global->icons[global->no_icons].name,"colors");
    global->icons[global->no_icons].width=global->levels;
    global->icons[global->no_icons].height=HEIGHT;
    for(i=0;i<global->levels;i++)
        for(j=0;j<HEIGHT;j++) XPutPixel(image,i,j,i);

    global->icons[global->no_icons].pixmap=XCreatePixmap(dpy,XDefaultRootWindow(dp
y),global->levels,HEIGHT,depth);

    XPutImage(dpy,global->icons[global->no_icons].pixmap,DefaultGC(dpy,scrn),image,0,0
,0,0,global->levels,HEIGHT);
    global->no_icons++;
    XtFree(image);
    fclose(fp);
}

#define done(type, value) \
{ \
    if (toVal->addr != NULL) { \
        if (toVal->size < sizeof(type)) { \
            toVal->size = sizeof(type); \
            return False; \
        } \
        *(type*)(toVal->addr) = (value); \
    } \
    else { \
        static type static_val; \
        static_val = (value); \
        toVal->addr = (XtPointer)&static_val; \
    } \
}

```

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```

        toVal->size = sizeof(type);
        return True;
    }

#define      dist(colora,colorb) \

abs(colora.red-colorb.red)+abs(colora.green-colorb.green)+abs(colora.blue-colorb.blue)

static Boolean CvtStringToPixel2(dpy, args, num_args, fromVal, toVal, closure_ret)
Display* dpy;
XrmValuePtr args;
Cardinal *num_args;
XrmValuePtr fromVal;
XrmValuePtr toVal;
XtPointer *closure_ret;
{
    String      str = (String)fromVal->addr;
    XColor      screenColor;
    XColor      exactColor;
    Screen      *screen;
    Colormap    colormap;
    Status      status;
    String      params[1];
    Cardinal    num_params=1;

    Dprintf("Convert string to pixel 2\n");
    if (*num_args != 2)
        XtAppErrorMsg(XtDisplayToApplicationContext(dpy), "wrongParameters",
"cvStringToPixel",
        "XtToolkitError",
        "String to pixel conversion needs screen and colormap arguments",
        (String *)NULL, (Cardinal *)NULL);

```

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```

screen = *((Screen **) args[0].addr);
colormap = *((Colormap *) args[1].addr);

if (!strcmp(str,XtDefaultBackground)) {
    *closure_ret = False;
    done(Pixel,WhitePixelOfScreen(screen));
}
if (!strcmp(str,XtDefaultForeground)) {
    *closure_ret = False;
    done(Pixel,BlackPixelOfScreen(screen));
}
params[0]=str;
if (0 == XParseColor(DisplayOfScreen(screen),colormap,str,&screenColor)) {
    XtAppWarningMsg(XtDisplayToApplicationContext(dpy), "noColormap",
"cvStringToPixel",
    "XtToolkitError", "Cannot parse color: \"%s\"",
params,&num_params);
    return False;
} else {
    if (0 == XAllocColor(DisplayOfScreen(screen),colormap,&screenColor)) {
        int    i, delta, closest=0;
        XColor    colors[global->levels];

        for(i=0;i<global->levels;i++) colors[i].pixel=i;

XQueryColors(DisplayOfScreen(screen),colormap,colors,global->levels);
        delta=dist(screenColor,colors[0]);
        for(i=1;i<global->levels;i++) {
            int    delta_new=dist(screenColor,colors[i]);

            if (delta_new<delta) {
                delta=delta_new;

```

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```

        closest=i;
    }
}

Dprintf("Closest color to %s is pixel %d red %d green %d blue
%d\n",str,colors[closest].pixel,colors[closest].red,colors[closest].green,colors[closest].blue
);

    *closure_ret = (char*)True;
    done(Pixel, closest);
} else {
    *closure_ret = (char*)True;
    done(Pixel, screenColor.pixel);
}
}
}

```

```
void Dispatch(list)
```

```
Batch list;
```

```

{
    if (list->next!=NULL) Dispatch(list->next);
    (list->proc)(NULL,list->closure,list->call_data);
    if (list->closure!=NULL) XtFree(list->closure);
    if (list->call_data!=NULL) XtFree(list->call_data);
    XtFree(list);
}

```

```
void BatchCtrl(w,closure,call_data)
```

```

Widget      w;
caddr_t     closure, call_data;

```

- 400 -

```

{
    Dprintf("BatchCtrl\n");
    global->batch=(String)closure;
}

void UnixShell(w,closure,call_data)

Widget      w;
caddr_t     closure, call_data;

{
    if (-1 == Fork((char **)closure)) Eprintf("Unable to fork\n");
}

void InitDither()

{
    int      i, j, k, l,
            dm4[4][4]={
                0, 8, 2, 10,
                12, 4, 14, 6,
                3, 11, 1, 9,
                15, 7, 13, 5
            };

    for(i=0;i<4;i++)
        for(j=0;j<4;j++)
            for(k=0;k<4;k++)
                for(l=0;l<4;l++)

global->dither[4*k+i][4*l+j]=(dm4[i][j]<<4)+dm4[k][l];
}

```

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source/Copy.h

```
typedef struct {  
    Video video;  
    char name[STRLEN], src_name[STRLEN];  
    int UVsample[2];  
    int mode;  
    Widget radioGroup;  
} CopyCtrlRec, *CopyCtrl;
```


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source/Gram.y

```
%{  
  
/*  
 *   Grammar for files: .elo  
 */  
  
#include    "../include/xwave.h"  
#include    "Klics.h"  
#include    "Transform.h"  
#include    "Copy.h"  
#include    "Video.h"  
  
extern void  VideoLoad();  
extern void  VideoSave();  
extern void  VideoDrop();  
extern void  ImportKlics();  
extern void  VideoAbekusSave();  
extern void  UnixShell();  
extern void  BatchCompCtrl();  
extern void  BatchTransCtrl();  
extern void  BatchCopyCtrl();  
extern void  BatchCompare();  
extern void  BatchCtrl();  
  
extern CompCtrl  InitCompCtrl();  
extern CopyCtrl  InitCopyCtrl();  
extern TransCtrl InitTransCtrl();  
  
static char  *ptr;  
void  NewBatch();  
  
%}
```

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%union

```
{
    double    fnum;
    int       num;
    char      *ptr;
    Boolean    bool;
};
```

%token SIZE TRANSFORM TRANSFORM_NONE TRANSFORM_WAVE PATH

%token FILE_PAL PALETTE RANGE LINE

%token FILE_VID TYPE FORMAT_MONO FORMAT_RGB FORMAT_YUV

RATE DISK GAMMA PATH FILES START END LEN DIM HEADER OFFSETS
NEGATIVE PRECISION%token FILE_BAT LOAD SAVE SAVE_ABEKUS COMPARE DROP
COMPRESS VIDEO_NAME STATS_NAME BIN_NAME%token STILL_MODE VIDEO_MODE AUTO_Q QUANT_CONST
THRESH_CONST BASE_FACTOR DIAG_FACTOR CHROME_FACTOR%token DECISION DEC_MAX DEC_SIGABS DEC_SIGSQR FEEDBACK
FILTER FLT_NONE FLT_EXP CMP_CONST SPACE LEFT_BRACE RIGHT_BRACE
DIRECTION

%token FPS BITRATE BUFFER XWAVE SHELL IMPORT_KLICS

%token COPY DIRECT_COPY DIFF LPF_WIPE LPF_ONLY RGB_YUV

%token < num > NUMBER

%token < ptr > STRING

%token < fnum > FNUMBER

%token < bool > BOOLEAN

%type < num > number video_type decision filter

%type < ptr > string

%type < fnum > fnumber

%type < bool > boolean

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%start wait

% %

wait :

```

| pal_id pal_desc
| video_id video_desc
| bat_id bat_desc bat_end;

```

pal_id : FILE_PAL {

Dprintf("Gram: palette file %s\n",global->parse_file);

};

video_id : FILE_VID {

Dprintf("Gram: video file %s\n",global->parse_file);

global->videos->start=1;

global->videos->size[2]=1;

};

bat_id : FILE_BAT {

Dprintf("Gram: batch file %s\n",global->parse_file);

};

pal_desc :

| pal_desc palette LEFT_BRACE mappings RIGHT_BRACE;

palette : PALETTE string {

Palette pal=(Palette)MALLOC(sizeof(PaletteRec));

Dprintf("Gram: palette %s\n", \$2);

strcpy(pal->name,\$2);

pal->mappings=NULL;

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```

    pal->next=global->palettes;
    global->palettes=pal;
    global->no_pals++;

```

};

mappings :

| mappings mapping;

```

mapping : RANGE number number LINE number number {
    Map map=(Map)MALLOC(sizeof(MapRec));

```

Dprintf("Gram: Range %d to %d m=%d c=%d\n", \$2, \$3, \$5, \$6);

map->start=\$2;

map->finish=\$3;

map->m=\$5;

map->c=\$6;

map->next=global->palettes->mappings;

global->palettes->mappings=map;

};

video_desc : video_defs {

if (global->videos->size[0]==0 &&

global->videos->size[1]==0) {

global->videos->size[0]=global->videos->cols;

global->videos->size[1]=global->videos->rows;

}

};

video_defs :

| video_defs video_def;

video_def : PATH string {

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```
Dprintf("Video path %s\n", $2);
strcpy(global->videos->path, $2);
}
| FILES string {
    Dprintf("Frames stored in %s\n", $2);
    strcpy(global->videos->files, $2);
}
| TYPE video_type {
    String types[] = {"Mono", "RGB", "YUV"};

    Dprintf("Video type: %s\n", types[$2]);
    global->videos->type = (VideoFormat)$2;
}
| RATE number {
    Dprintf("Video rate %d fps\n", $2);
    global->videos->rate = $2;
}
| DISK {
    Dprintf("Frames on disk\n");
    global->videos->disk = True;
}
| GAMMA {
    Dprintf("Gamma corrected\n");
    global->videos->gamma = True;
}
| NEGATIVE {
    Dprintf("Negative video\n");
    global->videos->negative = True;
}
| TRANSFORM video_transform
| START number {
    Dprintf("Video start %03d\n", $2);
```

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```
global->videos->start=$2;
}
| END number {
    Dprintf("Video end %03d\n",$2);
    global->videos->size[2]=$2-global->videos->start+1;
}
| LEN number {
    Dprintf("Video frames %d\n",$2);
    global->videos->size[2]=$2;
}
| DIM number number {
    Dprintf("Video dimensions %d %d\n",$2,$3);
    global->videos->cols=$2;
    global->videos->rows=$3;
}
| HEADER number {
    Dprintf("Video header size %d\n",$2);
    global->videos->offset=$2;
}
| OFFSETS number number {
    Dprintf("Video offsets %d %d\n",$2,$3);
    global->videos->x_offset=$2;
    global->videos->y_offset=$3;
}
| SIZE number number {
    Dprintf("Video size %d %d\n",$2,$3);
    global->videos->size[0]=$2;
    global->videos->size[1]=$3;
}
| PRECISION number {
    Dprintf("Video precision %d bits\n",8+$2);
    global->videos->precision=$2;
```

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```

};

video_type : FORMAT_MONO { $$=(int)MONO; }
            | FORMAT_RGB { $$=(int)RGB; }
            | FORMAT_YUV number number { $$=(int)YUV;
global->videos->UVsample[0]=$2; global->videos->UVsample[1]=$3; };

video_transform : TRANSFORM_NONE {
                global->videos->trans.type=TRANS_None;
            }
            | TRANSFORM_WAVE number number boolean {
                Dprintf("Video wavelet transformed %d %d
%s\n", $2, $3, $4?"True": "False");
                global->videos->trans.type=TRANS_Wave;
                global->videos->trans.wavelet.space[0]=$2;
                global->videos->trans.wavelet.space[1]=$3;
                global->videos->trans.wavelet.dirm=$4;
            };

bat_end :
        | XWAVE {
            Dprintf("Gram: XWAVE\n");
            NewBatch(BatchCtrl, (caddr_t) NULL, NULL);
        };

bat_desc : bat_cmds {
        Dprintf("Gram: End of batch file\n");
    };

bat_cmds :
        | bat_cmds bat_cmd;

```

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```

bat_cmd      : simple_cmd
               | complex_cmd
               ;

simple_cmd    : LOAD string {
               XawListReturnStruct *list_return=(XawListReturnStruct
               *)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: LOAD %s\n", $2);
               list_return->string = $2;
               NewBatch(VideoLoad, NULL, (caddr_t)list_return);
               }
               | SAVE string {
               XawListReturnStruct *list_return=(XawListReturnStruct
               *)MALLOC(sizeof(XawListReturnStruct));

               Dprintf("Gram: SAVE %s\n", $2);
               list_return->string = $2;
               NewBatch(VideoSave, NULL, (caddr_t)list_return);
               }
               | SAVE_ABEKUS string string string string {
               AbekusCtrl
               ctrl=(AbekusCtrl)MALLOC(sizeof(AbekusCtrlRec));

               Dprintf("Gram: SAVE_ABEKUS %s %s %s
               %s\n", $2, $3, $4, $5);

               strcpy(ctrl->names[0], $2);
               strcpy(ctrl->names[1], $3);
               strcpy(ctrl->names[2], $4);
               strcpy(ctrl->names[3], $5);
               NewBatch(VideoAbekusSave, (caddr_t)ctrl, NULL);
               }

```


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```

| COMPARE string string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: COMPARE %s with %s\n", $2, $3);
    list_return->string=$2;
    NewBatch(BatchCompare, (caddr_t)$3, (caddr_t)list_return);
}

| DROP string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: DROP %s\n", $2);
    list_return->string=$2;
    NewBatch(VideoDrop, NULL, (caddr_t)list_return);
}

| IMPORT_KLICS string {
    XawListReturnStruct *list_return=(XawListReturnStruct
*)MALLOC(sizeof(XawListReturnStruct));

    Dprintf("Gram: IMPORT_KLICS %s\n", $2);
    list_return->string=$2;
    NewBatch(ImportKlics, NULL, (caddr_t)list_return);
}

| SHELL string {
    char **argv, *str=$2;
    int c, argc=1, len=strlen(str);

    Dprintf("Shell %s\n", str);
    for(c=0; c<len; c++) if (str[c]==' ') {
        str[c]='\0';
        argc++;
    }
}

```

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```

    }
    argv=(char **)MALLOC((argc+1)*sizeof(char *));
    argc=0;
    for(c=0;c < len;c += 1 + strlen(str+c)) {
        argv[argc]=(char
*)MALLOC((strlen(str+c)+1)*sizeof(char));
        strcpy(argv[argc],str+c);
        argc++;
    }
    argv[argc]=NULL;
    NewBatch(UnixShell,(caddr_t)argv,NULL);
};

```

```

complex_cmd      : compress LEFT_BRACE comp_args RIGHT_BRACE
                  | transform LEFT_BRACE trans_args RIGHT_BRACE
                  | copy copy_arg;

```

```

compress        : COMPRESS string {
                  CompCtrl    ctrl=InitCompCtrl($2);

                  Dprintf("Gram: COMPRESS\n");
                  NewBatch(BatchCompCtrl,(caddr_t)ctrl,NULL);
                };

```

```

transform       : TRANSFORM string {
                  TransCtrl    ctrl=InitTransCtrl($2);

                  Dprintf("Gram: TRANSFORM\n");
                  NewBatch(BatchTransCtrl,(caddr_t)ctrl,NULL);
                };

```

```

copy           : COPY string string {

```

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```

CopyCtrl    ctrl=InitCopyCtrl($2);
Dprintf("Gram: Copy\n");
strcpy(ctrl->name,$3);
NewBatch(BatchCopyCtrl,(caddr_t)ctrl,NULL);
};

comp_args :
| comp_args comp_arg;

trans_args :
| trans_args trans_arg;

copy_arg : DIRECT_COPY number number {
    Dprintf("Gram: Direct Copy (sample %d %d)\n", $2, $3);
    ((CopyCtrl)global->batch_list->closure)->mode=1;

    ((CopyCtrl)global->batch_list->closure)->UVsample[0]=$2;

    ((CopyCtrl)global->batch_list->closure)->UVsample[1]=$3;
}
| DIFF {
    Dprintf("Gram: Differance Copy\n");
    ((CopyCtrl)global->batch_list->closure)->mode=2;
}
| LPF_WIPE {
    Dprintf("Gram: LPF zero\n");
    ((CopyCtrl)global->batch_list->closure)->mode=3;
}
| LPF_ONLY {
    Dprintf("Gram: LPF only\n");
    ((CopyCtrl)global->batch_list->closure)->mode=4;
}

```

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```

| RGB_YUV {
    Dprintf("Gram: RGB/YUV\n");
    ((CopyCtrl)global->batch_list->closure)->mode=5;
}

| GAMMA {
    Dprintf("Gram: Gamma convert\n");
    ((CopyCtrl)global->batch_list->closure)->mode=6;
};

comp_arg : VIDEO_NAME string {
    Dprintf("Gram: Compress name %s\n", $2);

    strcpy(((CompCtrl)global->batch_list->closure)->name, $2);
}

| STATS_NAME string {
    Dprintf("Gram: Stats name %s\n", $2);

    strcpy(((CompCtrl)global->batch_list->closure)->stats_name, $2);

    ((CompCtrl)global->batch_list->closure)->stats_switch=True;
}

| BIN_NAME string {
    Dprintf("Gram: Bin name %s\n", $2);

    strcpy(((CompCtrl)global->batch_list->closure)->bin_name, $2);

    ((CompCtrl)global->batch_list->closure)->bin_switch=True;
}

| STILL_MODE {
    Dprintf("Gram: Still\n");
    ((CompCtrl)global->batch_list->closure)->stillvid=True;
}

```

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```

| VIDEO_MODE {
    Dprintf("Gram: Video\n");
    ((CompCtrl)global->batch_list->closure)->stillvid=False;
}

| AUTO_Q boolean {
    Dprintf("Gram: Auto_q %s\n",$2?"True":"False");
    ((CompCtrl)global->batch_list->closure)->auto_q=$2;
}

| QUANT_CONST fnumber {
    Dprintf("Gram: Quant const %f\n",$2);

    ((CompCtrl)global->batch_list->closure)->quant_const=$2;
}

| THRESH_CONST fnumber {
    Dprintf("Gram: Thresh const %f\n",$2);

    ((CompCtrl)global->batch_list->closure)->thresh_const=$2;
}

| BASE_FACTOR number fnumber {
    Dprintf("Gram: Base factor oct %d=%f\n",$2,$3);

    ((CompCtrl)global->batch_list->closure)->base_factors[$2]=$3;
}

| DIAG_FACTOR fnumber {
    Dprintf("Gram: Diag factor %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->diag_factor=$2;
}

| CHROME_FACTOR fnumber {
    Dprintf("Gram: Chrome factor %f\n",$2);

    ((CompCtrl)global->batch_list->closure)->chrome_factor=$2;
}

```

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```

| DECISION decision {
    Dprintf("Gram: Decision changed\n");
    ((CompCtrl)global->batch_list->closure)->decide=$2;
}
| FEEDBACK number {
    ((CompCtrl)global->batch_list->closure)->feedback=$2;
    ((CompCtrl)global->batch_list->closure)->auto_q=True;
}
| FILTER filter {
    String filters[2]={"None","Exp"};
    Dprintf("Gram: Filter %s\n",filters[$2]);
    ((CompCtrl)global->batch_list->closure)->filter=$2;
}
| CMP_CONST fnumber {
    Dprintf("Gram: Comparison %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->cmp_const=$2;
}
| FPS fnumber {
    Dprintf("Gram: Frame Rate %f\n",$2);
    ((CompCtrl)global->batch_list->closure)->fps=$2;
}
| BITRATE number {
    Dprintf("Gram: %dx64k/s\n",$2);
    ((CompCtrl)global->batch_list->closure)->bitrate=$2;
}
| BUFFER {
    Dprintf("Gram: Buffer on\n");

    ((CompCtrl)global->batch_list->closure)->buf_switch=True;
};

```

```

decision      : DEC_MAX{ $$ = 0; }

```

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```

| DEC_SIGABS { $$ = 1; }
| DEC_SIGSQR { $$ = 2; };

```

```

filter      : FLT_NONE { $$ = 0; }
              | FLT_EXP { $$ = 1; };

```

```

trans_arg    : VIDEO_NAME string {
                Dprintf("Gram: Transform name %s\n", $2);

```

```

strcpy(((TransCtrl)global->batch_list->closure)->name, $2);
        }
        | DIRECTION boolean {
            Dprintf("Gram: Direction %s\n", $2?"True":"False");
            ((TransCtrl)global->batch_list->closure)->dirn=$2;
        }
        | SPACE number number {
            Dprintf("Gram: Space %d %d\n", $2, $3);
            ((TransCtrl)global->batch_list->closure)->space[0]=$2;
            ((TransCtrl)global->batch_list->closure)->space[1]=$3;
        }
        | PRECISION number {
            Dprintf("Gram: Precision %d bits\n", 8+$2);
            ((TransCtrl)global->batch_list->closure)->precision=$2;
        };

```

```

boolean      : BOOLEAN { $$ = $1; };

```

```

string : STRING {
    ptr = (char *)malloc(strlen($1)+1);
    strcpy(ptr, $1);
    ptr[strlen(ptr)-1] = '\0';
    $$ = ptr;

```

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};

fnumber : FNUMBER { \$\$ = \$1; };

number : NUMBER { \$\$ = \$1; };

%%

yyerror(s) char *s; {

Eprintf("Gram: error %s\n",s);

exit(3);

}

void NewBatch(proc,closure,call_data)

Proc proc;

caddr_t closure, call_data;

{

Batch bat=(Batch)MALLOC(sizeof(BatchRec));

bat->proc=proc;

bat->closure=closure;

bat->call_data=call_data;

bat->next=global->batch_list;

global->batch_list=bat;

}

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source/Klics.h

/* Block size - no not change */

#define BLOCK 2

typedef int Block[BLOCK][BLOCK]; /* small block */

/* tokens */

#define TOKENS 15

#define ZERO_STILL 0

#define NON_ZERO_STILL 1

#define BLOCK_SAME 2

#define ZERO_VID 3

#define BLOCK_CHANGE 4

#define LOCAL_ZERO 5

#define LOCAL_NON_ZERO 6

#define CHANNEL_ZERO 7

#define CHANNEL_NON_ZERO 8

#define OCT_ZERO 9

#define OCT_NON_ZERO 10

#define LPF_ZERO 11

#define LPF_NON_ZERO 12

#define LPF_LOC_ZERO 13

#define LPF_LOC_NON_ZERO 14

static int token_bits[TOKENS]

={1,1,1,2,2,1,1,1,1,1,1,1,1,1,1};

static unsigned char token_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

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/* decision algorithms */

#define MAXIMUM 0

#define SIGABS 1

#define SIGSQR 2

/* compression modes */

#define STILL 0

#define SEND 1

#define VOID 2

#define STOP 3

/* LookAhead histogram */

#define HISTO 400

#define HISTO_DELTA 20.0

#define HISTO_BITS 9

#include "../include/Bits.h"

typedef struct {

Video src, dst;

Boolean stillvid, stats_switch, bin_switch, auto_q, buf_switch;

double quant_const, thresh_const, cmp_const, fps,

base_factors[5], diag_factor, chrome_factor;

int bitrate, feedback, decide, filter;

char name[STRLEN], stats_name[STRLEN], bin_name[STRLEN],

src_name[STRLEN];

Bits bfp;

} CompCtrlRec, *CompCtrl;

typedef struct {

Boolean stillvid, auto_q, buf_switch;

double quant_const, thresh_const, cmp_const, fps,

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```
        base_factors[5], diag_factor, chrome_factor;
    int    decide;
    VideoFormat type;
    Boolean    disk, gamma;
    int    rate, start, size[3], UVsample[2];
    VideoTrans    trans;
    int    precision;
} KlicsHeaderRec, *KlicsHeader;
```

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source/KlicsSA.h

#include <stdio.h>

#include "Bits.h"

#define negif(bool,value) ((bool)?-(value):(value))

extern Bits bopen();

extern void bclose(), bread(), bwrite(), bflush();

/* Stand Alone definitions to replace VideoRec & CompCtrl assumes:

* video->type == YUV;

* video->UVsample[] = {1,1};

* video->trans.wavelet.space[] = {3,2};

* ctrl->bin_switch == True;

*/

#define SA_WIDTH 352

#define SA_HEIGHT 288

#define SA_PRECISION 2

static double base_factors[5] = {1.0,0.32,0.16,0.16,0.16};

#define diag_factor 1.4142136

#define chrome_factor 2.0

#define thresh_const 0.6

#define cmp_const 0.9

/* Block size - no not change */

#define BLOCK 2

typedef int Block[BLOCK][BLOCK]; /* small block */

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/* tokens */

#define TOKENS 15

#define ZERO_STILL 0

#define NON_ZERO_STILL 1

#define BLOCK_SAME 2

#define ZERO_VID 3

#define BLOCK_CHANGE 4

#define LOCAL_ZERO 5

#define LOCAL_NON_ZERO 6

#define CHANNEL_ZERO 7

#define CHANNEL_NON_ZERO 8

#define OCT_ZERO 9

#define OCT_NON_ZERO 10

#define LPF_ZERO 11

#define LPF_NON_ZERO 12

#define LPF_LOC_ZERO 13

#define LPF_LOC_NON_ZERO 14

static int token_bits[TOKENS]

={1,1,1,2,2,1,1,1,1,1,1,1,1,1,1};

static unsigned char token_codes[TOKENS]={0,1,0,1,3,0,1,0,1,0,1,0,1,0,1};

/* decision algorithms */

#define MAXIMUM 0

#define SIGABS 1

#define SIGSQR 2

/* compression modes */

#define STILL 0

#define SEND 1

#define VOID 2

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#define STOP 3

/* LookAhead histogram */

#define HISTO 400

#define HISTO_DELTA 20.0

#define HISTO_BITS 9

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source/Lex.l

%{

/*

* Lex driver for input files: .pal .vid .bat

*/

#include "../include/xwave.h"

#include "../include/Gram.h"

extern int ParseInput();

#undef unput

#undef input

#undef output

#undef feof

#define unput(c) ungetc(c,global->parse_fp)

#define input() ParseInput(global->parse_fp)

#define output(c) putchar(c)

#define feof() (1)

%}

number -?[0-9]+

fnumber -?[0-9]+"."[0-9]+

string \"([^\"]|\\.)*\">

%start WAIT MAP VIDEO BATCH BATCH_TRANS BATCH_COMP

%n 2000

%p 4000

%e 2000

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%%

```
"/*" { char c='\0';
```

```
while(c!='/') {
```

```
while (c!='*') c=input();
```

```
while (c=='*') c=input();
```

```
}
```

```
}
```

```
\.pal { BEGIN MAP; Dprintf("Lex: Reading palette file\n"); return(FILE_PAL); }
```

```
\.vid { BEGIN VIDEO; Dprintf("Lex: Reading video file\n"); return(FILE_VID); }
```

```
\.bat { BEGIN BATCH; Dprintf("Lex: Reading batch file\n"); return(FILE_BAT); }
```

```
{number} { (void)sscanf(yytext, "%d", &yyval.num); return(NUMBER); }
```

```
{string} { yyval.ptr = (char *)yytext; return(STRING); }
```

```
{fnumber} { (void)sscanf(yytext, "%lf", &yyval.fnum); return(FNUMBER); }
```

```
<MAP> Palette { return(PALETTE); }
```

```
<MAP> \{ { return(LEFT_BRACE); }
```

```
<MAP> \} { return(RIGHT_BRACE); }
```

```
<MAP> Range { return(RANGE); }
```

```
<MAP> Line { return(LINE); }
```

```
<VIDEO> Type { return(TYPE); }
```

```
<VIDEO> MONO { return(FORMAT_MONO); }
```

```
<VIDEO> RGB { return(FORMAT_RGB); }
```

```
<VIDEO> YUV { return(FORMAT_YUV); }
```

```
<VIDEO> Rate { return(RATE); }
```

```
<VIDEO> Disk { return(DISK); }
```

```
<VIDEO> Gamma { return(GAMMA); }
```

```
<VIDEO> Negative { return(NEGATIVE); }
```


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```

< VIDEO > Path          { return(PATH); }
< VIDEO > Files         { return(FILES); }
< VIDEO > Transform      { return(TRANSFORM); }
< VIDEO > None           { return(TRANSFORM_NONE); }
< VIDEO > Wavelet        { return(TRANSFORM_WAVE); }
< VIDEO > Start          { return(START); }
< VIDEO > End            { return(END); }
< VIDEO > Length         { return(LEN); }
< VIDEO > Dimensions     { return(DIM); }
< VIDEO > Header         { return(HEADER); }
< VIDEO > Offsets        { return(OFFSETS); }
< VIDEO > Size           { return(SIZE); }
< VIDEO > Precision      { return(PRECISION); }
< VIDEO > Yes             { yylval.bool=True; return(BOOLEAN); }
< VIDEO > No             { yylval.bool=False; return(BOOLEAN); }

< BATCH > Load           { return(LOAD); }
< BATCH > Save            { return(SAVE); }
< BATCH > SaveAbekus      { return(SAVE_ABEKUS); }
< BATCH > Compare         { return(COMPARE); }
< BATCH > Drop            { return(DROP); }
< BATCH > ImportKLICS     { return(IMPORT_KLICS); }
< BATCH > Transform       { BEGIN BATCH_TRANS; return(TRANSFORM); }
< BATCH > Compress        { BEGIN BATCH_COMP; return(COMPRESS); }
< BATCH > Xwave           { return(XWAVE); }
< BATCH > Shell           { return(SHELL); }
< BATCH > Copy            { return(COPY); }
< BATCH > Direct          { return(DIRECT_COPY); }
< BATCH > Diff            { return(DIFF); }
< BATCH > LPFzero         { return(LPF_WIPE); }
< BATCH > LPFonly         { return(LPF_ONLY); }
< BATCH > RGB-YUV         { return(RGB_YUV); }

```

< BATCH > Gamma { return(GAMMA); }

< BATCH_COMP > VideoName { return(VIDEO_NAME); }

< BATCH_COMP > Stats { return(STATS_NAME); }

< BATCH_COMP > Binary { return(BIN_NAME); }

< BATCH_COMP > Yes { yy1val.bool = True; return(BOOLEAN); }

< BATCH_COMP > No { yy1val.bool = False; return(BOOLEAN); }

< BATCH_COMP > Still { return(STILL_MODE); }

< BATCH_COMP > Video { return(VIDEO_MODE); }

< BATCH_COMP > AutoQuant { return(AUTO_Q); }

< BATCH_COMP > QuantConst { return(QUANT_CONST); }

< BATCH_COMP > ThreshConst { return(THRESH_CONST); }

< BATCH_COMP > BaseFactor { return(BASE_FACTOR); }

< BATCH_COMP > DiagFactor { return(DIAG_FACTOR); }

< BATCH_COMP > ChromeFactor { return(CHROME_FACTOR); }

< BATCH_COMP > Decision { return(DECISION); }

< BATCH_COMP > Feedback { return(FEEDBACK); }

< BATCH_COMP > Maximum { return(DEC_MAX); }

< BATCH_COMP > SigmaAbs { return(DEC_SIGABS); }

< BATCH_COMP > SigmaSqr { return(DEC_SIGSQR); }

< BATCH_COMP > Filter { return(FILTER); }

< BATCH_COMP > None { return(FLT_NONE); }

< BATCH_COMP > Exp { return(FLT_EXP); }

< BATCH_COMP > CmpConst { return(CMP_CONST); }

< BATCH_COMP > FrameRate { return(FPS); }

< BATCH_COMP > Bitrate { return(BITRATE); }

< BATCH_COMP > Buffer { return(BUFFER); }

< BATCH_COMP > \{ { return(LEFT_BRACE); }

< BATCH_COMP > \} { END; BEGIN BATCH;

return(RIGHT_BRACE); }

< BATCH_TRANS > VideoName { return(VIDEO_NAME); }

```
<BATCH_TRANS> Direction    { return(DIRECTION); }
<BATCH_TRANS> Space { return(SPACE); }
<BATCH_TRANS> Precision     { return(PRECISION); }
<BATCH_TRANS> Yes           { yyval.bool=True; return(BOOLEAN); }
<BATCH_TRANS> No            { yyval.bool=False; return(BOOLEAN); }
<BATCH_TRANS> \{            { return(LEFT_BRACE); }
<BATCH_TRANS> \}            { END; BEGIN BATCH; return(RIGHT_BRACE); }
```

```
[. \t\n]      { ; }
```

%%

```
yywrap() { return(1); }
```

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source/Transform.h

```
typedef struct {  
    Video src;  
    char  name[STRLEN], src_name[STRLEN];  
    int   space[2], precision;  
    Boolean dirn;  
} TransCtrlRec, *TransCtrl;
```

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source/Video.h

```
typedef struct {  
    char  names[4][STRLEN];  
} AbekusCtrlRec, *AbekusCtrl;
```

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source/makefile

Xwave Makefile

#

CFLAGS = -O -I../include

```
LIBS = -lXaw -lXmu -lXt -lXext -lX11 -lm -l -L/usr/openwin/lib
```

KEEP STATE:

SUFFIXES: .c .o

```
xwaveSRC = Select.c Convert.c xwave.c InitMain.c Pop2.c Video2.c Malloc.c
```

InitFrame.c \

Frame.c Transform.c Convolve3.c Update.c Image.c Menu.c

PullRightMenu.c \

NameButton.c SmeBSBpr.c Process.c Lex.c Gram.c Parse.c Color.c \

Bits.c Storage.c Copy.c Message.c Palette.c ImportKlics.c Icon3.c Klics5.c

KlicsSA.c KlicsTestSA.c ImportKlicsSA.c ImpKlicsTestSA.c

```
objDIR = ../$(ARCH)
```

```
xwaveOBJ = $(xwaveSRC:%.c=$(objDIR)/%.o)
```

\$(objDIR)/xwave: \$(xwaveOBJ)

gcc -o \$@ \$(xwaveOBJ) \$(LIBS) \$(CFLAGS)

[illegible]

```
$ (xwaveOBJ): $$(@F:.o=.c) ../include/xwave.h
```

```
gcc -c $(@F:.o=.c) $(CFLAGS) -o $@
```

Lex.c: Gram.c Lex.l

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```
lex Lex.l
```

```
mv lex.yy.c Lex.c
```

```
Gram.c: Gram.y
```

```
bison -dlt Gram.y
```

```
mv $(@F:.c=.tab.h) ../include/Gram.h
```

```
mv $(@F:.c=.tab.c) Gram.c
```

include/Bits.h

#ifndef _Bits_h

#define _Bits_h

```
typedef struct {  
    unsigned char buf;  
    int bufsize;  
    FILE *fp;  
} BitsRec, *Bits;
```

#endif

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include/DTheader.h

```
typedef struct DTheader {  
    char file_id[8];          /* "DT-IMAGE" */  
    char struct_id;          /* 1 */  
    char prod_id;            /* 4 */  
    char util_id;            /* 1 */  
    char board_id;           /* 2 */  
    char create_time[9]; /* [0-1]year, [2]month, [3]dayofmonth, [4]dayofweek,  
[5]hour, [6]min, [7]sec, [8]sec/100 */  
    char mod_time[9];        /* as create_time */  
    char datum;              /* 1 */  
    char datasize[4];        /* 1024?? */  
    char file_struct;        /* 1 */  
    char datatype;           /* 1 */  
    char compress;           /* 0 */  
    char store;              /* 1 */  
    char aspect[2];          /* 4, 3 */  
    char bpp;                /* 8 */  
    char spatial;            /* 1 */  
    char width[2];           /* 512 */  
    char height[2];          /* 512 */  
    char full_width[2];      /* 512 */  
    char full_height[2];     /* 512 */  
    char unused1[45];  
    char comment[160];  
    char unused2[256];  
} DTheader;
```

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include/icon.h

```
typedef      enum {  
    FW_label, FW_icon, FW_command, FW_text, FW_button, FW_icon_button,  
    FW_view, FW_toggle,  
    FW_yn,  
    FW_up, FW_down, FW_integer,  
    FW_scroll, FW_float,  
    FW_form,  
} FormWidgetType;
```

```
typedef      enum {  
    SW_below, SW_over, SW_top, SW_menu,  
} ShellWidgetType;
```

```
typedef      struct {  
    String name;  
    String contents;  
    int      fromHoriz, fromVert;  
    FormWidgetType type;  
    String hook;  
} FormItem;
```

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include/Image.h

/*

* \$XConsortium: Image.h,v 1.24 89/07/21 01:48:51 kit Exp \$

*/

/*****

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SOFTWARE.

*****/

```
#ifndef _XawImage_h
#define _XawImage_h
```

/******

*

* Image Widget

*

*****/

```
#include <X11/Xaw/Simple.h>
#include <X11/Xmu/Converters.h>
```

/* Resources:

Name	Class	RepType	Default Value
border	BorderColor	Pixel	XtDefaultForeground
borderWidth	BorderWidth	Dimension	1
cursor	Cursor	Cursor	None
destroyCallback	Callback	XtCallbackList	NULL
insensitiveBorder	Insensitive	Pixmap	Gray
mappedWhenManaged	MappedWhenManaged	Boolean	True
sensitive	Sensitive	Boolean	True
bitmap	Bitmap	Pixmap	NULL
callback	Callback	XtCallbackList	NULL
x	Position	Position	0

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y Position Position 0

*/

#define XtNbitmap "bitmap"

#define XtCBitmap "Bitmap"

/* Class record constants */

extern WidgetClass imageWidgetClass;

typedef struct _ImageClassRec *ImageWidgetClass;

typedef struct _ImageRec *ImageWidget;

#endif /* _XawImage_h */

/* DON'T ADD STUFF AFTER THIS #endif */

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include/ImageHeader.h

```

/* Author: Philip R. Thompson
 * Address: phils@athena.mit.edu, 9-526
 * Note: size of header should be 1024 (1K) bytes.
 * $Header: ImageHeader.h,v 1.2 89/02/13 09:01:36 phils Locked $
 * $Date: 89/02/13 09:01:36 $
 * $Source: /mit/phils/utis/RCS/ImageHeader.h,v $
 */

```

```

#define IMAGE_VERSION 3

```

```

typedef struct ImageHeader {
    char file_version[8]; /* header version */
    char header_size[8]; /* Size of file header in bytes */
    char image_width[8]; /* Width of the raster image */
    char image_height[8]; /* Height of the raster image */
    char num_colors[8]; /* Actual number of entries in c_map */
    char num_channels[8]; /* 0 or 1 = pixmap, 3 = RG&B buffers */
    char num_pictures[8]; /* Number of pictures in file */
    char alpha_channel[4]; /* Alpha channel flag */
    char runlength[4]; /* Runlength encoded flag */
    char author[48]; /* Name of who made it */
    char date[32]; /* Date and time image was made */
    char program[16]; /* Program that created this file */
    char comment[96]; /* other viewing info. for this image */
    unsigned char c_map[256][3]; /* RGB values of the pixmap indices */
} ImageHeader;

```

```

/* Note:

```

```

 * - All data is in char's in order to maintain easily portability

```

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- * across machines and some human readability.
- * - Images may be stored as pixmaps or in seperate channels, such as
- * red, green, blue data.
- * - An optional alpha channel is seperate and is found after every
- * num_channels of data.
- * - Pixmaps, red, green, blue, alpha and other channel data are stored
- * sequentially after the header.
- * - If num_channels = 1 or 0, a pixmap is assumed and up to num_colors
- * of colormap in the header are used.
- */

/***/ end ImageHeader.h ***/

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include/ImageP.h

/*

* \$XConsortium: ImageP.h,v 1.24 89/06/08 18:05:01 swick Exp \$

*/

/*****

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*****/

/*

* ImageP.h - Private definitions for Image widget

*

*/

#ifndef _XawImageP_h

#define _XawImageP_h

/******

*

* Image Widget Private Data

*

*****/

#include "../include/Image.h"

#include <X11/Xaw/SimpleP.h>

/* New fields for the Image widget class record */

typedef struct {int foo;} ImageClassPart;

/* Full class record declaration */

typedef struct _ImageClassRec {

CoreClassPart core_class;

SimpleClassPart simple_class;

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```

    ImageClassPart  image_class;
} ImageClassRec;

```

```

extern ImageClassRec imageClassRec;

```

```

/* New fields for the Image widget record */

```

```

typedef struct {

```

```

    /* resources */

```

```

        Pixmap      pixmap;

```

```

        XtCallbackList  callbacks;

```

```

    /* private state */

```

```

        Dimension    map_width, map_height;

```

```

} ImagePart;

```

```

/*****

```

```

 *

```

```

 * Full instance record declaration

```

```

 *

```

```

*****/

```

```

typedef struct _ImageRec {

```

```

    CorePart  core;

```

```

    SimplePart  simple;

```

```

    ImagePart  image;

```

```

} ImageRec;

```

```

#endif /* _XawImageP_h */

```

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include/Message.h

```
typedef struct {
    Widget      shell, widget; /* shell and text widgets (NULL if not created */
    XawTextBlock info; /* Display text */
    int  size, rows, cols; /* Size of buffer (info.ptr) & dimensions of display */
    XawTextEditType edit; /* edit type */
    Boolean  own_text; /* text is owned by message? */
} MessageRec, *Message;
```

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include/Palette.h

#define PalettePath "."

#define PaletteExt ".pal"

```
typedef struct _MapRec {
    int start, finish, m, c;
    struct _MapRec *next;
} MapRec, *Map;
```

```
typedef struct _PaletteRec {
    char name[STRLEN];
    Map mappings;
    struct _PaletteRec *next;
} PaletteRec, *Palette;
```

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include/PullRightMenu.h

/*

* \$XConsortium: PullRightMenu.h,v 1.17 89/12/11 15:01:55 kit Exp \$

*

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*

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*

*/

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```

/*
 * PullRightMenu.h - Public Header file for PullRightMenu widget.
 *
 * This is the public header file for the Athena PullRightMenu widget.
 * It is intended to provide one pane pulldown and popup menus within
 * the framework of the X Toolkit. As the name implies it is a first and
 * by no means complete implementation of menu code. It does not attempt to
 * fill the needs of all applications, but does allow a resource oriented
 * interface to menus.
 */

```

```

#ifndef _PullRightMenu_h
#define _PullRightMenu_h

```

```

#include <X11/Shell.h>
#include <X11/Xmu/Converters.h>

```

```

/*****
 *
 * PullRightMenu widget
 *
 *****/

```

```

/* PullRightMenu Resources:

```

Name	Class	RepType	Default Value
background	Background	Pixel	XtDefaultBackground
backgroundPixmap	BackgroundPixmap	Pixmap	None
borderColor	BorderColor	Pixel	XtDefaultForeground
borderPixmap	BorderPixmap	Pixmap	None

borderWidth	BorderWidth	Dimension	1
bottomMargin	VerticalMargins	Dimension	VerticalSpace
columnWidth	ColumnWidth	Dimension	Width of widest text
cursor	Cursor	Cursor	None
destroyCallback	Callback	Pointer	NULL
height	Height	Dimension	0
label	Label	String	NULL (No label)
labelClass	LabelClass	Pointer	smeBSBObjectClass
mappedWhenManaged	MappedWhenManaged	Boolean	True
rowHeight	RowHeight	Dimension	Height of Font
sensitive	Sensitive	Boolean	True
topMargin	VerticalMargins	Dimension	VerticalSpace
width	Width	Dimension	0
button	Widget	Widget	NULL
x	Position	Position	0
y	Position	Position	0

*/

```
typedef struct _PullRightMenuClassRec* PullRightMenuWidgetClass;
typedef struct _PullRightMenuRec* PullRightMenuWidget;
```

```
extern WidgetClass pullRightMenuWidgetClass;
```

```
#define XtNcursor "cursor"
#define XtNbottomMargin "bottomMargin"
#define XtNcolumnWidth "columnWidth"
#define XtNlabelClass "labelClass"
#define XtNmenuOnScreen "mcnuOnScreen"
#define XtNpopupOnEntry "popupOnEntry"
#define XtNrowHeight "rowHeight"
#define XtNtopMargin "topMargin"
```

```
#define XtNbutton    "button"
```

```
#define XtCColumnWidth "ColumnWidth"
```

```
#define XtCLabelClass "LabelClass"
```

```
#define XtCMenuOnScreen "MenuOnScreen"
```

```
#define XtCPopupOnEntry "PopupOnEntry"
```

```
#define XtCRowHeight "RowHeight"
```

```
#define XtCVerticalMargins "VerticalMargins"
```

```
#define      XtCWidget    "Widget"
```

```
/******
```

```
*
```

```
* Public Functions.
```

```
*
```

```
*****/
```

```
/*      Function Name: XawPullRightMenuAddGlobalActions
```

```
*      Description: adds the global actions to the simple menu widget.
```

```
*      Arguments: app_con - the appcontext.
```

```
*      Returns: none.
```

```
*/
```

```
void
```

```
XawpullRightMenuAddGlobalActions(/* app_con */);
```

```
/*
```

```
XtAppContext app_con;
```

```
*/
```

```
#endif /* _PullRightMenu_h */
```


include/SmeBSBpr.h

/*

* \$XConsortium: SmeBSB.h,v 1.5 89/12/11 15:20:14 kit Exp \$

*

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*/

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```

/*
 * SmeBSBpr.h - Public Header file for SmeBSB object.
 *
 * This is the public header file for the Athena BSB Sme object.
 * It is intended to be used with the simple inmenu widget. This object
 * provides bitmap - string - bitmap style entries.
 *
 */

```

```

#ifndef _SmeBSBpr_h
#define _SmeBSBpr_h

```

```

#include <X11/Xmu/Converters.h>

```

```

#include <X11/Xaw/Sme.h>

```

```

/*****

```

```

 *

```

```

 * SmeBSBpr object

```

```

 *

```

```

*****/

```

```

/* BSB pull-right Menu Entry Resources:

```

Name	Class	RepType	Default Value
callback	Callback	Callback	NULL
destroyCallback	Callback	Pointer	NULL
font	Font	XFontStruct *	XtDefaultFont
foreground	Foreground	Pixel	XtDefaultForeground
height	Height	Dimension	0
label	Label	String	Name of entry

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leftBitmap	LeftBitmap	Pixmap	None
leftMargin	HorizontalMargins	Dimension	4
rightBitmap	RightBitmap	Pixmap	None
rightMargin	HorizontalMargins	Dimension	4
sensitive	Sensitive	Boolean	True
vertSpace	VertSpace	int	25
width	Width	Dimension	0
x	Position	Position	0n
y	Position	Position	0
menuName	MenuName	String	"menu"

*/

```
typedef struct _SmeBSBprClassRec    *SmeBSBprObjectClass;
typedef struct _SmeBSBprRec         *SmeBSBprObject;
```

```
extern WidgetClass smeBSBprObjectClass;
```

```
#define XtNleftBitmap "leftBitmap"
```

```
#define XtNleftMargin "leftMargin"
```

```
#define XtNrightBitmap "rightBitmap"
```

```
#define XtNrightMargin "rightMargin"
```

```
#define XtNvertSpace "vertSpace"
```

```
#define XtNmenuName "menuName"
```

```
#define XtCLeftBitmap "LeftBitmap"
```

```
#define XtCHorizontalMargins "HorizontalMargins"
```

```
#define XtCRightBitmap "RightBitmap"
```

```
#define XtCVertSpace "VertSpace"
```

```
#define XtCMenuName "MenuName"
```

```
#endif /* _SmeBSBpr_h */
```

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include/SmeBSBprP.h

/*

* \$XConsortium: SmeBSBP.h,v 1.6 89/12/11 15:20:15 kit Exp \$

*

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*

* Author: Chris D. Peterson, MIT X Consortium

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*/

/*

* SmeP.h - Private definitions for Sme object

*

*/

#ifndef _XawSmeBSBP_h

#define _XawSmeBSBP_h

/*****

*

* Sme Object Private Data

*

*****/

#include <X11/Xaw/SmeP.h>

#include "../include/SmeBSBpr.h"

/*****

*

* New fields for the Sme Object class record.

*

*****/

typedef struct _SmeBSBprClassPart {

XtPointer extension;

} SmeBSBprClassPart;

/* Full class record declaration */

typedef struct _SmeBSBprClassRec {

RectObjClassPart rect_class;

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```

SmeClassPart    sme_class;
SmeBSBprClassPart sme_bsb_class;
} SmeBSBprClassRec;

extern SmeBSBprClassRec smeBSBprClassRec;

```

```

/* New fields for the Sme Object record */

```

```

typedef struct {
    /* resources */
    String label;          /* The entry label. */
    int vert_space;        /* extra vert space to leave, as a percentage
                           of the font height of the label. */
    Pixmap left_bitmap, right_bitmap; /* bitmaps to show. */
    Dimension left_margin, right_margin; /* left and right margins. */
    Pixel foreground;      /* foreground color. */
    XFontStruct * font;    /* The font to show label in. */
    XtJustify justify;     /* Justification for the label. */
    String menu_name;      /* Popup menu name */

```

```

/* private resources. */

```

```

Boolean set_values_area_cleared; /* Remember if we need to unhighlight. */
GC norm_gc;                      /* normal color gc. */
GC rev_gc;                       /* reverse color gc. */
GC norm_gray_gc;                 /* Normal color (grayed out) gc. */
GC invert_gc;                    /* gc for flipping colors. */

```

```

Dimension left_bitmap_width; /* size of each bitmap. */
Dimension left_bitmap_height;
Dimension right_bitmap_width;
Dimension right_bitmap_height;

```

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```
} SmeBSBprPart;
```

```
/******
```

```
*
```

```
* Full instance record declaration
```

```
*
```

```
*****/
```

```
typedef struct _SmeBSBprRec {
```

```
    ObjectPart    object;
```

```
    RectObjPart   rectangle;
```

```
    SmePart       sme;
```

```
    SmeBSBprPart  sme_bsb;
```

```
} SmeBSBprRec;
```

```
/******
```

```
*
```

```
* Private declarations.
```

```
*
```

```
*****/
```

```
#endif /* _XawSmeBSBPpr_h */
```

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include/xwave.h

```
#include <X11/Xlib.h>
#include <X11/Xutil.h>
#include <X11/Xatom.h>
#include <X11/Xaw/Cardinals.h>
#include <X11/StringDefs.h>
#include <X11/Xmu/Xmu.h>
#include <X11/Xaw/Command.h>
#include <X11/Xaw/List.h>
#include <X11/Xaw/Box.h>
#include <X11/Xaw/Form.h>
#include <X11/Xaw/Scrollbar.h>
#include <X11/Xaw/Viewport.h>
#include <X11/Xaw/AsciiText.h>
#include <X11/Xaw/Dialog.h>
#include <X11/Xaw/MenuButton.h>
#include <X11/Xaw/SimpleMenu.h>
#include <X11/Xaw/SmeBSB.h>
#include <X11/Xaw/Toggle.h>
#include "SmeBSBpr.h"
#include "PullRightMenu.h"
#include <X11/Shell.h>
#include <X11/cursorfont.h>
#define STRLEN 100
#define NAME_LEN 20
#include "Image.h"
#include "Message.h"
#include <dirent.h>
#include <math.h>
```


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```
#include    <stdio.h>
#include    "Palette.h"
#include    "Icon.h"

#define     PLOT_DIR    "graphs"
#define     PLOT_EXT    ".plot"
#define     ELLA_IN_DIR    "."
#define     ELLA_IN_EXT    ".eli"
#define     ELLA_OUT_DIR    "."
#define     ELLA_OUT_EXT    ".elo"
#define     VID_DIR    "videos"
#define     VID_EXT    ".vid"
#define     IMAGE_DIR    "images"
#define     BATCH_DIR    "batch"
#define     BATCH_EXT    ".bat"
#define     KLICS_DIR    "import"
#define     KLICS_EXT    ".klics"
#define     KLICS_SA_DIR    "import"
#define     KLICS_SA_EXT    ".klicsSA"

typedef enum {
    TRANS_None, TRANS_Wave,
} TransType;

typedef     enum {
    MONO, RGB, YUV,
} VideoFormat;

extern String ChannelName[3][4];

#define     negif(bool,value)    ((bool)?-(value):(value))
```

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```
typedef struct {
    String name;
    Pixmap pixmap;
    unsigned int height, width;
} IconRec, *Icon;
```

```
typedef void (*Proc)();
typedef String *(*ListProc)();
typedef Boolean (*BoolProc)();
```

```
typedef struct {
    String name;
    WidgetClass widgetClass;
    String label;
    String hook; /* menuName for smeBSBprObjectClass */
} MenuItem;
```

```
typedef struct {
    String name, button;
    ListProc list_proc;
    String action_name;
    Proc action_proc;
    caddr_t action_closure;
} SelectItem, *Selection;
```

```
typedef struct {
    TransType type;
    int space[2];
    Boolean dirn;
} WaveletTrans;
```

```
typedef union {
```

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```

    TransType    type;
    WaveletTrans  wavelet;
} VideoTrans;

```

```

typedef    struct _VideoRec    {
    char    name[STRLEN];          /* Name of this video name.vid */
    char    path[STRLEN];          /* Path to frame file(s) */
    char    files[STRLEN];         /* Name of frames files001 if not name */
    VideoFormat type;              /* Type of video (MONO,RGB,YUV) */
    Boolean    disk; /* Frames reside on disk rather than in memory */
    Boolean    gamma;              /* Gamma corrected flag */
    Boolean    negative;           /* Load negative values in data */
    int    rate;                  /* Frames per second */
    int    start;                 /* Starting frame number */
    int    size[3]; /* Dimensions of video after extraction x, y and z */
    int    UVsample[2];           /* Chrominance sub-sampling x and y */
    int    offset;                /* Header length */
    int    cols, rows;            /* Dimensions of video as stored */
    int    x_offset, y_offset; /* Offset of extracted video in stored */
    VideoTrans  trans;            /* Transform technique used */
    int    precision;             /* Storage precision above 8 bits */
    short **data[3];              /* Image data channels */
    struct _VideoRec *next;       /* Next video in list */
} VideoRec, *Video;

```

```

typedef    struct {
    Video video;
    char    name[STRLEN];
} VideoCtrlRec, *VideoCtrl;

```

```

typedef    struct _PointRec    {
    int    location[2];

```

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```
int    usage;
struct _PointRec  *next;
} PointRec, *Point;

typedef    struct _FrameRec  {
    Widget      shell, image_widget, point_merge_widget;
    Video video;
    int    zoom, frame, channel, palette;
    Boolean    point_switch, point_merge;
    Point point;
    Message    msg;
    struct _FrameRec  *next;
} FrameRec, *Frame;
```

```
#define    NO_CMAPS 6
```

```
typedef    struct _BatchRec  {
    Proc  proc;
    caddr_t    closure, call_data;
    struct _BatchRec  *next;
} BatchRec, *Batch;
```

```
typedef    struct {
    char    home[STRLEN];
    XtAppContext    app_con;
    Widget    toplevel;
    int    no_icons;
    Icon    icons;
    Video videos;
    Frame frames;
    Point points;
    Palette    palettes;
```

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```
int    no_pals;
String parse_file;
String parse_token;
FILE   *parse_fp;
XVisualInfo *visinfo;
int    levels, rgb_levels, yuv_levels[3];
Colormap  cmaps[NO_CMAPS];
String batch;
Batch batch_list;
Boolean  debug;
int    dither[16][16];
} GlobalRec, *Global;
```

```
typedef struct {
    Widget    widgets[3];
    int    max, min, *value;
    String format;
} NumInputRec, *NumInput;
```

```
typedef struct {
    Widget    widgets[2];
    double    max, min, *value;
    String format;
} FloatInputRec, *FloatInput;
```

```
extern Global    global;
```

```
/* InitFrame.c */
```

```
extern Video FindVideo();
```

```
/* Pop2.c */
```

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```
extern void  NA();
extern Widget  FindWidget();
extern void  Destroy();
extern void  Free();
```

```
/* Storage.c */
```

```
extern void  NewFrame();
extern void  GetFrame();
extern void  SaveFrame();
extern void  FreeFrame();
extern void  SaveHeader();
extern Video CopyHeader();
```

```
/* Message.c */
```

```
extern void  TextSize();
extern Message  NewMessage();
extern void  MessageWindow();
extern void  CloseMessage();
extern void  Mprintf();
extern void  Dprintf();
extern void  Eprintf();
extern void  Mflush();
```

```
/* Icon3.c */
```

```
extern void  FillForm();
extern void  FillMenu();
extern Widget  ShellWidget();
extern Widget  FormatWidget();
extern void  SimpleMenu();
```

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```
extern int    TextWidth();
extern Icon   FindIcon();
extern void   NumIncDec();
extern void   FloatIncDec();
extern void   ChangeYN();
extern XFontStruct *FindFont();
```

DATA COMPRESSION AND DECOMPRESSION
GREGORY KNOWLES AND ADRIAN S. LEWIS
M-2357 US
APPENDIX B-1


```

MAC_ADDR_COUNTER_COL = (bool:ck,1_reset:reset,STRING[xsize]bit:block_cnt_length)
->
(t_col,bool):
BEGIN
MAKE BASE_COUNTER_COL:base_counter_col.
JOIN (ck,reset:block_cnt_length) ->base_counter_col.

OUTPUT (base_counter_col[1], CASE base_counter_col[2]
      OF
      ELSE 1
      ESAC)

END.

MAC_ADDR_COUNTER_ROW = (bool:ck,1_reset:reset,STRING[ysize]bit:block_cnt_length,bool:col_carry)
->
(t_row,bool):
BEGIN
MAKE BASE_COUNTER_ROW:base_counter_row.
JOIN (ck,reset,col_carry:block_cnt_length,CASE col_carry #type conversion#
      OF t:count_carry
      ELSE count_rst
      ESAC) ->base_counter_row.

OUTPUT (base_counter_row[1], CASE base_counter_row[2]
      OF count_carry:1
      ELSE 1
      ESAC)

END.

#the string base address calculators#

```

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```
MAC NOMULT_MAC_READ = (bool:ck.t_reset:reset,bool:col_end.t_mux4:mux_control,STRING[17]bit:incr,
  STRING[17]bit:oct_add_factor, STRING[19]bit:base_u_base_v)
```

```
->
  STRING[19]bit:
```

```
BEGIN
```

```
  MAKE ADD_US_ACTEL[19,17]:add,
```

```
    MUX_2[STRING[17]bit]:mux.
```

```
LET
```

```
  next_addr = MUX_4[STRING[19]bit](add[2..20],ZERO[19]b'0',base_u_base_v,mux_control),
  diff = DIFF_NO_LOAD[STRING[19]bit](ck,reset,next_addr,b"000000000000000000000000").
```

```
JOIN  (diff,mux,b'1)  ->add,
      (incr,oct_add_factor,CASE col_end
        OF t:right
         ELSE left
         ESAC)
      ->mux.
```

```
OUTPUT  diff
END.
```

```
MAC S_SPA =(STRING[19]bit:in)
```

```
->
```

```
  (flag,t_sparc_addr):BIOP TRANSFORM_US.
MAC SPA_S =(t_sparc_addr:in)
```

```
->
```

```
  (flag,STRING[19]bit):BIOP TRANSFORM_US.
```

```
MAC SPARC_ADDR= (bool:ck.t_reset:reset,bool:col_end.t_mux4:mux_control,[2]t_sparc_addr:oct_add_factor,
```

```

        STRING[19]bit:base_u base_v)
    ->
        t_sparc_addr:

BEGIN
    LET out=NOMULT_MAC_READ(ck,reset,col_end,mux_control,(SPA_S oct_add_factor[1])[2][3..19],
        (SPA_S oct_add_factor[2])[2][3..19]base_u base_v).
    OUTPUT (S_SPA out)[2]
END.

#-----#

#the read and write address generator,input the initial image & block sizes for oct/0 at that channel#
FN ADDR_GEN_NOSCRATCH= (bool:ck,t_reset:reset,t_direction:direction,t_channel:channel,
    STRING[9]bit:x_p_1,STRING[11]bit:x3_p_1,STRING[12]bit:x7_p_1,
    STRING [ysize]bit:octave_row_length,STRING [xsize]bit:octave_col_length,t_reset:octave_reset,
    t_octave:octave,bool:y_done,bool:y_done,t_load:octave_finished,STRING [19]bit:base_u base_v)

    ->
        ((t_input_mux,t_sparcport,t_dwtport#dwt#),t_load#DWT data valid#,t_load#read_valid#,
            t_count_control#row read col read#,(t_col,t_count_control)#addr_col_read#):
#the current octave and when the block finishes the 3 octave transform#
BEGIN

    # ADDR_COUNTER_ROW:addr_row_write,#
    # ADDR_COUNTER_COL:addr_col_write,#
    MAKE ROW_COUNT_CARRY:addr_row_read,
        COL_COUNT: addr_col_read,
        SPARC_ADDR:write_addr read_addr,
        MEM_CONTROL_NOSCRATCH:mem_control,

```

#write begins #

JKFF:zero_hh_bool read_done_bool.

LET mem_sel

```

      = CASE octave
OF    oct/0:uno,
      oct/1:dos,
      oct/2:tres,
      oct/3:quatro
ESAC,

```

```

sparm_add_1      = MUX_4{t_sparm_addr}{
  (addr/1),
  (addr/2),
  (addr/4),
  (addr/8),
  mem_sel},

```

```

sparm_add_2_y    = MUX_4{STRING[12]bit}(
  (b"00000000000001"),
  (b"000" CONC x_p_1[1..7] CONC b"10"),
  (b"0" CONC x3_p_1[1..8] CONC b"100"),
  (x7_p_1[1..8] CONC b"1000"),
  mem_sel),

```

```

sparm_add_2_uv   = MUX_4{STRING[12]bit}(
  (b"00000000000001"),
  (b"000" CONC x_p_1[1..6] CONC b"10"),
  (b"00" CONC x3_p_1[1..7] CONC b"100"),
  (b"0" CONC x7_p_1[1..7] CONC b"1000"),
  mem_sel),

```

```

sparm_add_2      = MUX_2{STRING[12]bit}(sparm_add_2_y, sparm_add_2_uv, CASE channel

```

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OF y:left
ELSE right
ESAC),

sparc_oel_add_factor = (sparc_add_1(S_SPA(b'00000000" CONC sparc_add_2)))[2]),

#signals when write must start delayed 1 tu for use in zero_hh#

addr_col_read_flag = CASE addr_col_read[2]#decode to bool#
OF count_carry:1
ELSE 1
ESAC,

write_latency = CASE (addr_row_read[1], addr_col_read[1])
OF (row/2,col/(conv2d_latency-1)):1
ELSE 1
ESAC,

read_done = CASE (addr_row_read[2], addr_col_read_flag) #read input data done#
OF (count_carry:1)
ELSE 1
ESAC,

zero_hh = CAST(!_load)(NOT zero_hh_bool),

read_valid = CAST(!_load)(NOT read_done_bool),

start_write_col = DFF_NO_LOAD(!_load)(ck,reset,zero_hh,read), #1 tu after zero_hh#

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```

read_mux = CASE (y_done,uv_done,octave_finished,channel)
OF
  (t.f,write,y)((f.f,write,u):tres, #base_u#
  (t.f,write,u)((f.f,write,v):quatro, #base_v#
  (t.f,write,y):dos #base_y#
ELSE uno
ESAC,

```

```

write_mux = CASE zero_hh
OF write: uno,
  read:
    CASE channel
    OF y: dos, #base_y#
       u: tres, #base_u#
       v: quatro #base_v#
    ESAC
  ESAC

```

JOIN

#note that all the counters have to be reset at the end of an octave, ie on octave_finished#

```

(ck.octave_reset,octave_col_length) ->addr_col_read, #the row&col counts for the read address#
(ck.octave_reset,octave_row_length,addr_col_read(2)) ->addr_row_read,

```

```

(ck.octave_reset,write_latency,t) ->zero_hh_bool,

```

```

(ck.octave_reset,read_done,t) ->read_done_bool,

```

#w&r addresses for sparc mem#

```

(ck.reset,PDF1{bool,conv2d_latency-1})(ck.reset,addr_col_read_flag,f).write_mux,sparc_oct_add_factor,base_u,base_v)
->write_addr,

```

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```
(ck,reset,addr_col_read_flag,read_mux,spare_oct_add_factor,base_u,base_v) ->read_addr,
```

```
(ck,reset,direction,channel,octave,write_addr,read_addr,zero_hh) ->mem_control.
```

```
OUTPUT( mem_control.zero_hh, read_valid,addr_row_read[2],addr_col_read)
END.
```

```
#the basic 2d convolver for transform, rows first then cols.#
```

```
FN CONV_2D = (bool:ck,t_reset:reset, t_input:in, t_direction:direction, [4]t_scratch:pdal,
  t_reset:conv_reset,t_count_control:row_flag,(t_col,t_count_control):addr_col_read)
```

```
->
```

```
(t_input,t_memport,t_count_control,t_count_control,t_count_control):
```

```
#forward direction outputs in row form #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
# HH HG HH HG ..... #
# HG GG HG GG ..... #
```

```
#the inverse convolver returns the raster scan format output data#
```

```
#the convolver automatically returns a 3 octave transform#
```

```
BEGIN
```

```
FN CH_PORT = ([4]t_scratch,t_col),t_col)
```

```
->
```

```
t_memport:REFORM.
```

```
MAKE CONV_ROW:conv_row,
  CONV_COL:conv_col.
```

```
LET
```

```

row_reset = CASE direction
OF forward:conv_reset,
   inverse:PDF1(t_reset,1)(ck,no_rst,conv_reset,rst)   #pipeline delays in col_conv#
ESAC,
col_reset = CASE direction
OF forward:PDF1(t_reset,3)(ck,no_rst,conv_reset,rst),
   inverse:conv_reset   #pipeline delays in row_conv#
ESAC,

col_flag = DFM(t_count_control)(ck,addr_col_read[2],PDF1(t_count_control,1)(ck,reset,addr_col_read[2],
count_0), CAST[bool]direction),

row_control = DFM(t_count_control)(ck,PDF1(t_count_control,3)(ck,reset,row_flag,count_0),
row_flag, CAST[bool]direction),

direction_sel =CASE direction   #mux control for the in/out data mux's#
OF forward:left,
   inverse:right
ESAC,

col_count = MUX_2((t_col,t_count_control))((
PDF1((t_col,t_count_control),3)(ck,reset,addr_col_read,(col/0,count_rst)),
addr_col_read,
direction_sel),

#pipeline delays for the convolver values and input value#
del_conv_col=DFF_NO_LOAD(t_input)(ck,reset,conv_col[1],input/0),

del_conv_row=DFF_NO_LOAD(t_input)(ck,reset,conv_row,input/0),

del_in = DFF_NO_LOAD(t_input)(ck,reset,in,input/0).

```


JOIN

(ck,row_reset,direction,MUX_2[t_input])(del_in,del_conv_col,direction_sel), col_flag) ->conv_row,

(ck,col_reset,direction,MUX_2[t_input])(del_conv_row,del_in,direction_sel), pdel,row_control,col_count) ->conv_col.

OUTPUT (MUX_2[t_input])(del_conv_col,del_conv_row, direction_sel),CH_PORT(conv_col[2],col_count[1]),row_control,col_count[2],col_flag)
END.

1d col convolver, with control

FN CONV_COL = (bool:ck,t_reset:reset,t_direction:direction, t_input:in,

[4]t_scratch:pdcl,t_count_control:row_flag,

(t_col,t_count_control):col_count)

->

(t_input,([4]t_scratch,t_col)):

#input is data in and, pdcl, out from line-delay memories#

out is (G,H), and line delay out port. The row counter is started 1 cycle later to allow for#

#pipeline delay between MULTIPLIER and this unit #

BEGIN

a %2 line by fine resettable counter for the state machines, out->one on rst#

#carry active on last element of row#

MAC COUNT_2 = (bool:ck,t_reset:reset,t_count_control:carry)

->

t_count_2:

BEGIN

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```

    MAKE DFF_NO_LOAD[l_count_2]:countdel.
    LET countout= CASE (countdel,carry)
      OF (one,count_carry):two,
         (two,count_carry):one
      ELSE countdel
      ESAC.
    JOIN (ck,reset,countout,one) ->countdel.
    OUTPUT countdel
    END.

```

```

#the code for the convolver#
MAKE MULT_ADD:mult_add,
  [4]DF1[l_scratch]:pdel_in,
  [4]DF1[l_scratch]:pdel_out,
  COUNT_2:count.

```

```

# now the state machines to control the convolver#
#First the and gates#

```

```

LET      reset_row=DF1[l_reset](ck,reset),      #starts row counter 1 cycle after frame start#
#we want the row counter to be 1 cycle behind the col counter for the delay for the#
#pipelined line delay memory#

```

```

col_carry =DFF_NO_LOAD[l_count_control](ck,reset,col_count[2],count_rst),

```

```

#these need to be synchronised to keep the row counter aligned with the data stream#
#also the delay on col_count deglitches the col carryout#

```

```

row_control=row_flag,      #signal for row=0,1,2,3, last row, etc#

```

```

andset=(CASE direction
OF forward: CASE count
OF one:pass,
two:zero
ESAC,
inverse: CASE count
OF one:zero,
two:pass
ESAC
ESAC,
CASE row_control
OF count_0:zero
ELSE pass
ESAC,
CASE direction
OF forward: CASE row_control
OF count_0:zero
ELSE pass
ESAC,
inverse: pass
ESAC),
#now the add/sub control for the convolver address#
addset= CASE count
OF one:(add,add,add,sub),
two:(add,sub,add,add)
ESAC,

```

```

#now the mux control#
centermuxsel=

CASE direction
OF forward: CASE count
    OF one:(left,right),
       two:(right,left)
    ESAC,
    inverse:CASE count
    OF one:(right,left),
       two:(left,right)
    ESAC

#the perfect reconstruction output#
#the addmuxsel signal#
muxandtsel =

CASE direction
OF forward:(andtsel[2],pass,andtsel[2]),
   inverse:(pass,andtsel[2], CASE row_control
    OF count_1 zero
    ELSE pass
    ESAC)

    ESAC,
muxsel= CASE direction
    OF forward:(uno,

CASE row_control
OF count_0:dos,
   count_carry:tres
   ELSE uno
   ESAC,

CASE row_control
OF count_0:tres,

```

```

count_carry:quatro
ELSE dos
ESAC).

```

```

inverse:( CASE row_control
OF count_0:dos,
count_1:quatro,
count_carry:dos,
count_lm1:tres
ELSE dos
ESAC,

```

```

CASE row_control
OF count_0:tres,
count_carry:dos
ELSE uno
ESAC,

```

```

uno)

```

```

ESAC.

```

```

LET

```

```

#ACTEL#

```

```

wr_addr      =DF1(it_col)(ck,DF1(it_col)(ck,col_count[1])),
              #need 2 delays between wr and rd addr#
rd_addr=col_count[1].
              #address for line delay memory#

```

```

#join the control signals to the mult_add block#
JOIN  (ck,reset_row,col_carry)->count,

```

```

(ck,reset,in,andsel,centermuxsel,muxsel,muxandsel,addsel,direction,ptel_out)  ->mult_add.

```

```

FOR INT k=1..4 JOIN
    (ck_mult_add[k])->pdel_in[k],    #delay to catch the write address#
    (ck_pdel[k])    ->pdel_out[k].    #read delay to match MULT delay#

#ACTEL HACK#
LET gh_select = CASE (direction,DF1(t_count_2)(ck_count) )
    OF (inverse,one)((forward,two):right,
        (inverse,two)((forward,one):left
        ESAC,

    gh_out = MUX_2(t_scratch)(pdel_in[4],DF1(t_scratch)(ck_pdel_out[1]),gh_select),
    shift_const= CASE direction
    OF inverse: CASE DF1(t_count_control)(ck_row_control)
        OF (count_1|count_2):shift3
        ELSE shift4
        ESAC,
        forward: shift5
        ESAC.

    OUTPUT (ROUND_BITS(gh_out,shift_const),(pdel_in,wr_addr#rd_addr#))    #LOCAMII#
END.
#the 1d convolver, with control and coeff extend#

FN CONV_ROW =(bool:ck,t_reset:reset,t_direction:direction,t_input:in,t_count_control:col_flag)
->
    t_input:

    # out is (G,H). The row counter is started 1 cycle later to allow for#
    #pipeline delay between MULTIPLIER and this unit #
    #the strings give the col & row lengths for this octave#

```

```

BEGIN
    # a %2 line by line resetable counter for the state machines, out->one on rst#
    MAC COUNT_2 = (bool:ck,t_reset:reset)
    -> t_count_2:

    BEGIN
        MAKE DFF_NO_LOAD(t_count_2):countdel.
        LET countout= CASE (countdel)
            OF (one):two,
               (two):one
            ESAC.
        JOIN (ck,reset,countout,one) ->countdel.
        OUTPUT countdel
        END.

    #the code for the convolver#
    MAKE MULT_ADD:mult_add,
    {4}DFF1(t_scratch):pdel,
    COUNT_2:count.

    # now the state machines to control the convolver#
    #First the and gates#

    LET

    reset_col=DFF1(t_reset)(ck,reset),      #starts row counter 1 cycle after frame start#
    #makes up for the pipeline delay in MULT#
    #L1LATENCY DECODER#
    col_control=col_flag,                  #flag when col_count=0,1,2,col_length,etc#

```

```

andsel=(CASE direction
OF forward: CASE count
OF one:pass,
two:zero
ESAC,
Inverse: CASE count
OF one:zero,
two:pass
ESAC
ESAC,
CASE col_control
OF count_0:zero
ELSE pass
ESAC,
CASE direction
OF forward: CASE col_control
OF count_0:zero
ELSE pass
ESAC,
Inverse: pass
ESAC),
#now the add/sub control for the convolver address#
addsel= CASE count
OF one:(add,add,add,sub),
two: (add,sub,add,add)
ESAC,
#now the mux control#

```



```

centermuxsel=
CASE direction
OF forward: CASE count
    OF one:(left,right),
       two:(right,left)
    ESAC,
    inverse: CASE count
    OF one:(right,left),
       two:(left,right)
    ESAC
ESAC,

#the addmuxsel signal#
muxandsel =
CASE direction
OF forward:(andsel[2],pass,andsel[2]),
   inverse:(pass,andsel[2], CASE col_control
    OF count_1:zero
    ELSE pass
    ESAC)
ESAC,
muxsel=
CASE direction
OF forward:(uno,
CASE col_control
OF count_0:dos,
   count_carry:tres
ELSE uno
ESAC,
CASE col_control
OF count_0:tres,
   count_carry:quatro
ELSE dos

```

ESAC),

```
inverse:( CASE col_control
OF count_0:dos,
   count_1:quatro,
   count_lm1:tres
ELSE dos
ESAC,
```

```
CASE col_control
OF count_0:tres,
   count_carry:dos
ELSE uno
ESAC,
```

uno)

ESAC.

#join the control signals to the mult_add block#

```
JOIN (ck,reset_col) ->count,
```

#set up the col counters #

```
(ck,reset,in,andsel,centermuxsel,muxsel,muxandsel,addsel,direction,pdel)->mult_add.
```

FOR INT j=1..4 JOIN

```
(ck,mult_add[j]) ->pdel[j]. #pipeline delay for mult-add unit#
```

#ACTEL HACK#

```
LET gh_select=CASE direction
```

```
OF inverse: CASE count
   OF one:left,
```

```

        two:right
        ESAC,
        forward: CASE count
        OF one:right,
        two:left
        ESAC
        ESAC,

        gh_out = MUX_2(t_scratch)(pdel[4],DF1(t_scratch)(ck, pdel[1]),gh_select),

        rb_select= CASE direction
        OF inverse:CASE col_control
        OF (count_2 | count_3):shift3
        ELSE shift4
        ESAC,
        forward: shift5
        ESAC.

        OUTPUT ROUND_BITS(gh_out,rb_select)
        END.

        #some string macros#
        MAC EQ_US = (STRING(INT n)bit: a b)
        ->
        bool: BIOP EQ_US.

        #ACTEL 8 bit comparator macro#
        FN ICMP8 = (STRING[8]bit: a b)
        ->
        bool: EQ_US[8](a,b).

```

```

#.....#
#A set of buclean ,ie gate level counters      #
#.....#

#.....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle ,outputs are q and tc (toggle for next counter#
#stage                                           #
#.....#

```

```

MAC BASIC_COUNT = (bool:ck ,l_reset:reset,bool: tog)
->
[2]bool:

```

```

BEGIN

    MAKE DFF_NO_LOAD[bool]:dlat,
        XOR :xor,
        AND :and.

    JOIN (ck,reset,xor,f)->dlat,
        (dlat,tog) ->and,
        (tog,dlat) ->xor.
    OUTPUT (dlat,and)

END.

#.....#
# The n-bit macro counter generator, en is the enable, the outputs #
#are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
#.....#

MAC COUNT_SYNC[INT n] = (bool:ck,l_reset: reset,bool: en )

```

```

->
((n)bool,bool):

(LET out = BASIC_COUNT(ck,reset,en) .

    OUTPUT IF n=1
    THEN ((1)out[1],out[2])
    ELSE (LET outn = COUNT_SYNC(n-1)(ck,reset,out[2]) .
        OUTPUT (outn[1]CONC out[1],outn[2])
        )
    FI
).

#a mod 2^xsize counter#
MAC MOD2_COUNTER_COL = (bool:ck,t_reset:reset)
->

BEGIN (t_col):

    MAC S_TO_C = (STRING(xsize)bit:n)
->

    MAKE COUNT_SYNC(xsize):count,
    BOOL_STRING(xsize):b_s.

    JOIN (ck,reset,t) ->count, #count always enabled#
    count[1]->b_s.
    OUTPUT (S_TO_C b_s)[2]
    END.

#a mod 2^ysize counter#
MAC MOD2_COUNTER_ROW = (bool:ck,t_reset:reset,bool:en)

```

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```

->
BEGIN
  MAC S_TO_R = (STRING[ysize]bit.in)
  (t_row):

  MAKE COUNT_SYNC[ysize]:count,
  BOOL_STRING[ysize]b_s.
  (flag,t_row):BIOP TRANSFORM_US.

  JOIN (ck,reset,en) ->count,
  count[i] ->b_s.
  OUTPUT (S_TO_R b_s)[2]
  END.

#the basic mod col_length counter, to be synthesised#
MAC BASE_COUNTER_COL = (bool:ck,t_reset:reset,STRING[xsize]bit:octave_cnt_length)
->
(t_col,t_count_control):

BEGIN
  MAC C_TO_S = (t_col: in)
  (flag,STRING[xsize]bit):BIOP TRANSFORM_US.

  MAC FINAL_COUNT = (t_col:in,STRING[xsize]bit:octave_cnt_length)
  t_count_control:
  BEGIN
    LET in_us = (C_TO_S in)[2].
    lsb=in_us[xsize].
    #OUTPUT CASE EQ_US(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) the msb's are the same#
    #ACTEL#

```

```

OUTPUT CASE ICMP8(in_us[1..xsize-1],octave_cnt_length[1..xsize-1]) #the msb's are the same#
OF t: CASE lsb      #so check the lsb#
  OF b'1:count_carry, #count odd, so must be length#
    b'0:count_lm1     #count is even so must be length-1#
    ESAC
  ELSE count_rst
  ESAC
END.

MAKE MOD2_COUNTER_COL:mod2_count,
FINAL_COUNT:final_count.

JOIN (mod2_count,octave_cnt_length)      ->final_count,
      (ck,CASE reset                      #system reset or delayed carryout reset#
      OF rst: rst
      ELSECASE DFF_NO_LOAD(t_count_control)(ck,reset,final_count,count_0) #latch to avoid glitches#
        OF count_carry:rst
        ELSE no_rst
        ESAC
      ESAC)
      ->mod2_count.

OUTPUT (mod2_count,final_count)
END.

FN COL_COUNT_ST = (bool:ck,t_reset:reset,STRING(xsize)bit:octave_cnt_length)
-->
      (t_col,t_count_control):
      #count value , and flag for count=0,1,2,col_length-1,col_length#

BEGIN
  MAKE BASE_COUNTER_COL:base_col.

  LET count_control = CASE reset

```

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```

OF rst:count_0
  ELSE CASE base_col[1]
    OF
      col/0:count_0,
      col/1:count_1,
      col/2:count_2,
      col/3:count_3
    ELSE base_col[2]
      ESAC
    ESAC.
  JOIN (ck, reset, octave_cnt_length) -> base_col.
  OUTPUT (base_col[1], count_control)
END.

#the basic mod row_length counter, to be synthesised#
MAC BASE_COUNTER_ROW = (bool:ck, t_reset:reset, bool:en, STRING[ysize]bit:octave_cnt_length, t_count_control:col_carry)
->
  (t_row, t_count_control):

BEGIN
  MAC R_TO_S = (t_row:in)
  ->
    (flag, STRING[ysize]bit): BIOP TRANSFORM_US.
  MAC FINAL_COUNT = (t_row:in, STRING[ysize]bit:octave_cnt_length)
  ->
    t_count_control:

BEGIN
  LET in_us = (R_TO_S in)[2],
    lsb=in_us[ysize].
  #OUTPUT CASE EQ_US(in_us[1..ysize-1], octave_cnt_length[1..ysize-1]) the msb's are the same#

```



```

#ACTEL#
  OUTPUT CASE ICMP8(in_us[1..ysize-1],octave_cnt_length[1..ysize-1]) #the msb's are the same#
    OF 1:CASE lsb
      #so check the lsb#
      OF b'1:count_carry. #count odd, so must be length#
        b'0:count_lm1 #count is even so must be length-1#
          ESAC
        ELSE count_rst
          ESAC
      END.
    MAKE MOD2_COUNTER_ROW:mod2_count,
    FINAL_COUNT:final_count.

#need to delay the reset at end of count signal till end of final row#
#WAS DFF WITH reset#
  LET count_reset = DF1(!_reset)(ck,CASE(final_count,col_carry) #last row/last col#
    OF (count_carry,count_carry):rst #latch to avoid glitches#
      ELSE no_rst
        ESAC).

JOIN (mod2_count,octave_cnt_length) -> final_count,
(ck,CASE reset
  OF rst:rst
    ELSE count_reset
      ESAC,en) -> mod2_count.
  OUTPUT (mod2_count,final_count)
  END.

FN ROW_COUNT_CARRY_ST = (bool:ck,1_reset:reset,STRING[ysize]bit:octave_cnt_length,t_count_control:col_carry)
->
  (!_row,t_count_control):

```

```

BEGIN
    MAKE BASE_COUNTER_ROW base_row.
    LET count_control = CASE reset
        OF rst:count_0
            ELSE CASE base_row[1]
                OF row/0:count_0,
                    row/1:count_1,
                    row/2:count_2,
                    row/3:count_3
                    ELSE base_row[2]
                    ESAC
                ESAC.
            JOIN (ck,reset,CASE col_carry
                OF count_carry:1
                ELSE 1
                ESAC,octave_cnt_length,col_carry) ->base_row.
            OUTPUT (base_row[1],count_control)
            END.
        #the discrete wavelet transform chip/ multi-octave/2d transform with edge compensation#
        #when ext & csl are both low latch the setup params from the nubus(active low), as follows#
        #ad[1..4] select function#
        # 0000 load max_octaves, luminance/colour, forward/inversebar#
        # 0001 load yimage#
        # 0010 load ximage#
        #jump table values#
        # 0011 load ximage+1#
        # 0100 load 3ximage+3#
        # 0101 load 7ximage+7#

```

```

#      0110  load base u addr#
#      0111  load base v addr#

#adl[21..22]  max_octaves#
#adl[23]luminance/crominancebar active low, 1 is luminance, 0 is colour#
#adl[24]forward/inversebar active low, 1 is forward, 0 is inverse#

#adl[5..24]  data (bit 24 lsb)#

FN ST_OCT = (STRING[2]bit:st)
->          (llag,l_octave): BIOP TRANSFORM_US.

FN OCT_ST = (l_octave:st)
->          (llag,STRING[2]bit):BIOP TRANSFORM_US.

FN DWT = (bool:ck_in,l_reset_in,l_input_in_in,bcol:extwritel_in cel_in,STRING[24]bit:adl,
          l_input_sparc_mem_in,[4]l_scratch:pdcl_in)

->          (l_input#out IDWT data#[3]l_load#valid out IDWT data,y,u,v#,
          [3]l_load#valid in DWT data y,u,v#,
          l_sparcport#sparc_data_addr, etc#,
          l_mempport#pdcl_data_out#):

BEGIN
MAKE CONV_2D:conv_2d,
ADDR_GEN_NOSCRATCH:addr_gen,
#active low clock &enable latches#

```

```

[2]DLE1D:max_octave_sl,
DLE1D:channel_factor_sl,
DLE1D:dir,
[9]DLE1D:col_length_s,
[9]DLE1D:row_length_s,
[9]DLE1D:x_p_1,
[11]DLE1D:x3_p_1,
[12]DLE1D:x7_p_1,
[19]DLE1D:base_u,
[19]DLE1D:base_v,
#active low 3X8 decoder#
DEC3X8A          :decodel,
#the octave control#
DFF_INIT[t_octave]: octave ,
DFF_INIT[t_channel]: channel ,
JKFF:row_carry_ff,
#pads#
INBUF[STRING[24]bit]:adl_out,
CLKBUF:ck,
INBUF[bool]:extwritel_csl,
INBUF[t_reset]:reset,
INBUF[t_input]:in_sparc_mem,
INBUF[[4]t_scratch]:pdel,
OBHS[t_input]:out1,
OBHS[[3]t_load]:out2 out3,
OBHS[t_sparcport]:out4,
OBHS[t_memport]:out5,
#must delay the write control to match the data output of conv_2d, ie by conv2d_latency#
LET
#set up the control params#

```

```

max_oct = (ST_OCT_BOOL_STRING[2]max_octave_s)[2],
channel_factor= CAST((channel_factor)channel_factor_sl,
col_length = BOOL_STRING[9] col_length_s,
row_length = BOOL_STRING[9] row_length_s,

direction =CASE dir
  OF  f:forward,
      t:inverse
      ESAC,

#set up the octave params#
convcol_row= conv_2d[3],
convcol_col=conv_2d[4],
convrow_col=conv_2d[5],
#signals that conv_col, for forward, or conv_row, for inverse, has finished that octave#
#and selects the next octave value and the sub-image sizes#

octave_finished =CASE direction
  OF  forward:CASE (row_carry_ff,convcol_row,convcol_col)
      OF (l,count_2,count_2):write #row then col, gives write latency#
      ELSE read
      ESAC,
      inverse:CASE (row_carry_ff,convcol_row,convrow_col)
      OF (l,count_2,count_3):write #extra row as col then row#
      ELSE read
      ESAC
      ESAC,
#max octaves for ul/v#

```

ESAC;

```

CASE (y_done,uv_done)
OF
  (t,bool)/((bool,t):new_oct:=oct/0
ELSE
  ESAC
),

```

```

inverse:(CASE octave
OF
  oct/3:new_oct:=oct/2,
  oct/2:new_oct:=oct/1,
  oct/1:new_oct:=oct/0
ESAC;

```

CASE channel

```

OF
  y: CASE octave
    OF
      oct/0: CASE channel_factor #watch for colour#
        OF
          luminance:new_oct:=max_oct
          ELSE
            new_oct:=max_oct_1
          ESAC

```

ELSE

ESAC,

u: CASE octave

```

  OF
    oct/0:new_oct:=max_oct_1
  ELSE

```

ESAC,

v: CASE octave

```

  OF
    oct/0:new_oct:=max_oct
  ELSE
    #move to y#
  ESAC

```

ESAC)

```

ESAC;
CASE channel_factor
OF luminance:new_channel:=y,
   color: (CASE (channel,y_done)
OF (y,t):new_channel:=u
ELSE
ESAC;
CASE (channel,uv_done)
OF (u,t):new_channel:=v,
   (v,t):new_channel:=y
ELSE
ESAC)
ELSE
ESAC;
OUTPUT (new_od,new_channel)
),

octave_sel = CASE (octave,channel) #the block size divides by 2 every octave#
OF (oct/0,y):uno, #the uv image starts 1/4 size#
   (oct/1,y):(oct/0,uv):dos,
   (oct/2,y):(oct/1,uv):tres,
   (oct/3,y):(oct/2,uv):quatro
ESAC,
octave_row_length = MUX_4[STRING [ysize]bit](row_length,b*0" CONC row_length[1..ysize-1],
   b*00" CONC row_length[1..ysize-2],
   b*000" CONC row_length[1..ysize-3],octave_sel),
octave_col_length = MUX_4[STRING [xsize]bit](col_length,b*0" CONC col_length[1..xsize-1],
   b*00" CONC col_length[1..xsize-2],
   b*000" CONC col_length[1..xsize-3],octave_sel),

```

```

#bad next octave, either on system reset, or write finished#
load_octave= CASE reset
               OF rst:write
               ELSE octave_finished
               ESAC,

#reset the convolvers at the end of an octave, ready for the next octave#
#latch pulse to clean it, note 2 reset pulses at frame start#
#cant glitch as reset&octave_finished dont change at similar times#
conv_reset = CASE reset
               OF rst:rst
               ELSE CASE DFF_NO_LOAD[!_load](ck,reset, octave_finished,read)
               OF write:rst
               ELSE no_rst
               ESAC
               ESAC,

#latch control data off nubus, latch control is active low#
gl = CASE (extwrite!,cs1)
      OF (!,1):1
      ELSE 1
      ESAC,

sparc_w=addr_gen[1][2][1], #write addresses#

input_mux=addr_gen[1][1], #input_mux#

sparc_r=addr_gen[1][2][2], #read addresses#

sparc_rw = addr_gen[1][2][3].

```



```

inverse_out = CASE (direction,octave)
OF (inverse,oct/0):CASE (channel,addr_gen[2])
  OF (y,write):(write,read,read),
     (u,write):(read,write,read),
     (v,write):(read,read,write)
  ELSE (read,read,read)
  ESAC,
  (forward,oct/0):(read,read,read)
ELSE (read,read,read)
ESAC,
forward_in = CASE direction
OF forward:CASE (channel,octave,addr_gen[3])
  OF (y,oct/0,read):(read,write,write),
     (u,oct/0,read):(write,read,write),
     (v,oct/0,read):(write,write,read)
  ELSE (write,write,write)
  ESAC,
  inverse:(write,write,write)
ESAC.

JOIN
#in pads#
  ck_in      ->ck,
  reset_in->reset,
  extwritel_in  ->extwritel,
  csl_in       ->csl,
  adl         ->adl_out,
  in_in       ->in,
  spare_mem_in ->spare_mem,
  pdel_in     ->pdel,
#out pads#

```

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```

conv_2d[1]      ->out1,
inverse_out     ->out2,
forward_in      ->out3,
addr_gen[1][2]  ->out4,
conv_2d[2] ->out5,

```

#the control section#

```

(CAST[bool]adl[4],CAST[bool]adl[3],CAST[bool]adl[2]) ->decodel,      #active low outs#

(gi,decode[1],BIT_BOOLadl_out[21]) ->max_octave_sl[1],
(gi,decode[1],BIT_BOOLadl_out[22]) ->max_octave_st[2],

(gi,decode[1],BIT_BOOLadl_out[23]) ->channel_factor_sl,
(gi,decode[1],BIT_BOOLadl_out[24]) ->dir.

FOR INT j=1..9 JOIN
  (gi,decode[2],BIT_BOOLadl_out[15+j]) ->col_length_sl[j],
  (gi,decode[3],BIT_BOOLadl_out[15+j]) ->row_length_sl[j],
  (gi,decode[4],BIT_BOOLadl_out[15+j]) ->x_p_1[j].

FOR INT j=1..11 JOIN
  (gi,decode[5],BIT_BOOLadl_out[13+j]) ->x3_p_1[j].

FOR INT j=1..12 JOIN
  (gi,decode[6],BIT_BOOLadl_out[12+j]) ->x7_p_1[j].

FOR INT j=1..19 JOIN
  (gi,decode[7],BIT_BOOLadl_out[5+j]) ->base_sl[j],
  (gi,decode[8],BIT_BOOLadl_out[5+j]) ->base_v[j].

```

#sets a flag when row counter moves onto next frame#

```

JOIN
  (ck.conv_reset,CASE convcol_row
    OF count_carry1
    ELSE 1

```

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ESAC,i) ->row_carry_ff,

#load the new octave, after the current octave has finished writing#
 # on initial reset must load with starting octave value which depends on direction and channel#

```
(ck,no_rst,load_octave, CASE reset
  OF no_rst:next[1]
  ELSE CASE (direction,channel) #initial octave#
    OF (forward,t_channel):oct0,
      (inverse,y):max_oct,
      (inverse,uv):max_oct_1
    ESAC
    ESAC,oct0)                      ->octave, #next octave#
(ck,no_rst,load_octave, CASE reset
  OF no_rst:next[2]
  ELSE y
  ESAC,y)                      ->channel, #next channel#
```

```
(ck,reset,MUX_2[t_input](in,sparc_mem,CASE input_mux #input_mux#
  OF dwt_in:left,
    sparc_in:right
  ESAC)
,direction,pdel, conv_reset,addr_gen[4],addr_gen[5])                      ->conv_2d,
```

```
(ck,reset,direction,channel,BOOL_STRING[9]x_p_1,BOOL_STRING[11]x3_p_1,BOOL_STRING[12]x7_p_1,octave_row_length,
octave_col_length,conv_reset,octave,y_done,uv_done,octave_finished,BOOL_STRING[19]base_u,BOOL_STRING[19]base_v)                      ->addr_gen.
```

OUTPUT (out1 ,out2,out3,out4,out5)

END.

FN DWT_TEST = (bool:ck_in,i, reset:reset_in, t_input:in_in,bool:extwritel_in,col_in,t_sparc_addr:reg_sel value)

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```

->
(t_input,[3]t_load,[3]t_load):

BEGIN
  FN SPARC_MEM = (t_input.in,t_sparc_addr.wr_addr,t_sparc_addr.rd_addr,t_load.rw_sparc#t_cs.cs#)
  ->
    t_input:
    RAM(input/0).

    MAKE DWT:dwt,
    SPARC_MEM:sparc_mem,
    LINE_DELAY(t_scratch):line_delay.

  LET
    data_out=dwt[1],
    sparc_port=dwt[4],
    line_delay_port = dwt[5].

  JOIN
    (ck_in,reset_in,in_in,extwritel_in,cs1_in,(SPA_S_reg_sel)[2][16..19]CONC b*1* CONC(NOT_B (SPA_S_value)[2]),sparc_mem,line_delay)
    ->dwt,
    (data_out,sparc_port[1],sparc_port[2],sparc_port[3],sparc_port[4])# ->sparc_mem,
    (line_delay_port[1],line_delay_port[2],line_delay_port[3],write) ->line_delay.

  OUTPUT  dwt[1..3]
  END.

# some basic macros for the convolver, assume these will#
#be synthesised into leaf cells#
#the actual MX4 mux cell#
FN NOT = (bool:in)
->
  bool:CASE in OF 1:1,1:1 ESAC.

```

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MAC MX_4[TYPE ty]=(ty:in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel
OF (t,f):in1,
(t,f):in2,
(t,f):in3,
(t,f):in4

ESAC.

#the actel GMX4 mux cell#

MAC GMX4[TYPE ty]=(ty:in1 in2 in3 in4, [2]bool:sel)

->

ty:

CASE sel
OF (t,f):in1,
(t,f):in2,
(t,f):in3,
(t,f):in4

ESAC.

MAC MXT[TYPE ty]=(ty:a b c d, bool:soa sob s1)

->

ty:

CASE s1
OF t: CASE soa
OF tb
ELSE a
ESAC,
t: CASE sob

```

OF t:d
ELSE c
ESAC
ESAC.
MAC ENCODE4_2 = (t_mux4.in)
->
[2]bool:
CASE in
OF uno:(t,f),
dos:(t,t),
tres:(t,f),
quatro:(t,t)
ESAC.

MAC ENCODE3_2 = (t_mux3.in)
->
[2]bool:
CASE in
OF t:(t,f),
c:(t,t),
r:(t,f)
ESAC.

FN DEC3X8A = (bool:a b c)
->
[8]bool:
CASE (a,b,c)
OF (t,t,f):(t,t,t,t,t,t,t,t),
(t,t,f):(t,t,t,t,t,t,t,t),
(t,t,f):(t,t,t,t,t,t,t,t),
(t,t,f):(t,t,t,t,t,t,t,t),

```

```

(1,1):(1,1,1,1,1,1),
(1,1):(1,1,1,1,1,1),
(1,1):(1,1,1,1,1,1),
(1,1):(1,1,1,1,1,1)

```

ESAC.

MAC_MUX_2(TYPE 0)=(in1 in2, l_muxsel)

->

t:

CASE sel

OF left:in1,

right:in2

ESAC.

MAC_MUX_3(TYPE 0)=(in1 in2 in3, l_mux3sel)

->

t:

MX_4(t)(in1,in2,in3,in1,ENCODE3_2 sel).

COM

MAC_MUX_4(TYPE 0)=(in1 in2 in3 in4, l_mux4sel)

->

t:

CASE sel

OF uno:in1,

dos:in2,

tres:in3,

quatro:in4

ESAC.

MOC

```

MAC MUX_4(TYPE t)=(t.in1 in2 in3 in4, t_mux4.sel)
->
t:
MX_4(t.in1,in2,in3,in4,ENCODE4_2.sel).

FN AND2 = (bool:a b)
->
bool:BIOP AND.

MAC GNAND2 = (bool:a b)
->
bool:NOT AND2(a,b).

MAC AND_2 = (t_scratch.in, t_and.sel)
->
t_scratch:
BEGIN
LET in_s = (t_TO_S(scratch_exp)in)[2],
sel_s = CAST[bool]sel.
OUTPUT (S_TO_I(scratch_exp)BOOL_STRING(scratch_exp) ((INT j=1..scratch_exp)AND2(BIT_BOOL in_s[j],sel_s) ))[2]
END.

FN XOR = (bool: a b)
->
bool:
CASE (a,b)
OF (1,1):(1,1):1
ELSE 1
ESAC.

```



```

MAC XOR_B(INT n) = (STRING[n]bit:a b)
->
STRING[n]bit:BIOP XOR.

MAC NOT_B = (STRING[INT n]bit:a)
->
STRING[n]bit:BIOP NOT.

MAC XNOR_B = (STRING[INT n]bit:a b)
->
STRING[n]bit:
NOT_B XOR_B(n)(a,b).

FN AND = (bool: a b)
->
bool:
CASE (a,b)
OF (1,1):1
ELSE 1
ESAC.

MAC DEL(TYPE t) = (t)
->
t:DELAY(?t,t).

#a general dff same as DFF_NO_LOAD#
MAC DFF (TYPE t)=(bool:ck,t_reset:reset,t_in init_value)
->
t:
BEGIN

```

```

MAKE DEL(i):del.
JOIN in->del.
OUTPUT CASE reset
  OF rstinit_value
    ELSE del
      ESAC
END.

```

```

#a general dfi#
MAC DF1 (TYPE i)=(bool:ck,t:in)
->
t:
BEGIN
MAKE DEL(i):del.
JOIN in->del.
OUTPUT del
END.

```

```

#a general latch#
MAC DL1 (TYPE ty)=(bool:ck,ty:in)
->
ty:
BEGIN
MAKE DEL(ty):del.
JOIN CASE ck
  OF t:in
    ELSE del
      ESAC ->del.
OUTPUT CASE ck
  OF t:in

```

```

ELSE del
ESAC

END.

#a general d latch#
MAC LATCH (TYPE t)=(bool:ck,t_load:load,t:in)
->
t:
BEGIN
MAKE DEL(t).del.
LET out=CASE load
OF write:in
ELSE del
ESAC.
JOIN out->del.
OUTPUT out
END.

#an ACTEL D LATCH#
MAC DLEID = (bool:ckl loadl,bool:in)
->
bool:#qn#
NOT LATCH(bool)(NOT ckl, CASE loadl
OF t:write
ELSE read
ESAC, in).

MAC PDFI(TYPE t,INT n) = (bool:ck,t_reset:reset,t:in initial_value)
->
t:
IF n=0 THEN DFFI(t,ck,reset,in,initial_value)

```

```

ELSE PDF1(i,n-1)(ck,reset,DFF1)(ck,reset,in,initial_value),initial_value)
FI.

```

```

#a muxed input dff#
MAC DFM (TYPE ty)=(bool:ck,ty:a b,bool:s)
->
ty:
BEGIN
MAKE DEL(ty):del.
JOIN CASE s
  OF fa,
    tb
  ESAC ->del.
OUTPUT del
END.
#a resettable DFF, init value is input parameter#
MAC DFF_INIT(TYPE t)=(bool:ck,t_reset:reset,t_load:load,t_in init_value)
->
t:
BEGIN
MAKE DEL(t):del.
LET out=CASE (load,reset)
  OF (write,t_reset):in,
    (read,reset):init_value
  ELSE del
  ESAC.
JOIN out->del.
OUTPUT CASE reset
  OF rst:init_value
  ELSE del

```

ESAC
END.

#a resetable JKFF, k Input is active low#
FN JKFF=(bool:ck,t_reset:reset,bool:j k)

->

bool:
BEGIN
MAKE DEL(bool):del.
LET out=CASE (j,k,reset)
OF (t,t,no_reset):t,
 (t,t,reset):t,
 (t,t,no_reset):t,
 (t,t,no_reset):del,
 (t,t,no_reset):NOT del

ESAC.

JOIN out->del.

OUTPUT CASE reset

OF rst:t

ELSE del

ESAC

END.

#a dff resetable non-loadable dff#

MAC DFF_NO_LOAD(TYPE t)=(bool:ck,t_reset:reset,t,in init_value)

->

t:
BEGIN
MAKE DEL(t):del.
JOIN in->del.

```

OUTPUT CASE reset
OF rst_init_value
ELSE del
ESAC
END.

```

MAC PDEL{TYPE t,INT n} = (t:n)

↑ ↓

```
IF n=0 THEN DEL(j)in
ELSE PDEL(j,n-1) DEL(j) in
FI.
```

```
#the mem control unit for the DWT chip, outputs the memport values for the spare, and dwt#
#inputs datain from these 2 ports and mux's it to the 2d convolver.#
```

```
MAC MEM_CONTROL_NOSCRATCH = (bool:ck,t_reset:reset,t_direction:direction,t_channel:channel,t_octave:octave,
                               t_sparc_addr:sparc_addr,w_sparc_addr_r,t_loadzero_hh)
```

↑

((t_input_mux,t_sparcport,t_dwtport#dwt#):

BEGIN

the comb. logic for the control of the I/O ports of the chip#

LET ports = (SEQ

VAR #defaults. so ? doesnt kill previous mem value#

rw_spac:=read,

rw_dwt:=read,

cs_dwt:=no_select,

```
input_mux:=sparc_in;
```

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```

CASE (direction,octave)
OF
  (forward,oct/0): ( cs_dwt:=select;
                    input_mux:=dwt_in),

  (inverse,oct/0): ( CASE zero_hh
                    OF  write:(rw_dwt:=write;
                                cs_dwt:=select)
                    ELSE
                    ESAC)

ESAC;

#rw_sparc:=write when ck=1 and zero_hh=write, otherwise = read#
rw_sparc:= CAST(t_load)GNAND2(NOT CAST(bool)zero_hh,ck);

#mux the sparc addr on clock#
sparc_addr = GIMX4(t_sparc_addr)(sparc_r,sparc_r,sparc_w,sparc_w,ck,f);#

OUTPUT (input_mux, (sparc_addr_w,sparc_addr_r,rw_sparc), #sparc port#
        (rw_dwt,cs_dwt)
        #dwt port#
        )
).
OUTPUT ports
END.

# the basic 1d convolver without the control unit#

MAC MULT_ADD = (bool:ck,t_reset: reset,t_input:in, [3]t_and:andsel, [2]t_mux:centermuxsel,[3]t_mux4:muxsel,
                [3]t_and:muxandsel,[4]t_add:address, t_direction:direction,[4]t_scratch:pdel)

->
[4]t_scratch: #pdel are the outputs from the line delays#

```

```

BEGIN
    MAKE MULTIPLIER:mult,
    [4]ADD_SUB: add.
#the multiplier outputs#
    LET x3=mult[1],
        x5=mult[2],
        x11=mult[3],
        x19=mult[4],
        x2=mult[5],
        x8=mult[6],
        x30=mult[7],
#the mux outputs#
        mux1=MUX_4(t_scratch)(x11,x5,x8,x2,muxsel[1]),
        mux2=MUX_4(t_scratch)(x19,x30,x8,scratch0,muxsel[2]),
        mux3=MUX_4(t_scratch)(x11,x5,x8,x2,muxsel[3]),
        centermux=(MUX_2(t_scratch)(pdel[1],pdel[3],centermuxsel[1]),
            MUX_2(t_scratch)(pdel[2],pdel[4],centermuxsel[2]) ),
# the AND gates zero the adder inputs every 2nd row#
#the and gate outputs#
        and1=AND_2(pdel[2],andsel[1]),
        and2=AND_2(pdel[3],andsel[1]),
        and3=AND_2(centermux[1],andsel[2]),
        and4=AND_2(centermux[2],andsel[3]),
        add1in=AND_2(mux1,muxandsel[1]),

```


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```

add3in=AND_2(mux3,muxandse[2]).
add4in=AND_2(x3,muxandse[3]).

```

```

JOIN  in  ->mult,
      (and1,add1in,addse[1]) ->add[1],
      (and3,mux2,addse[2])  ->add[2],
      (and4,add3in,addse[3]) ->add[3],
      (and2,add4in,addse[4]) ->add[4].

```

OUTPUT add

END.

the basic multiplier unit of the convolver

```

MAC MULTIPLIER_ST = (l_input:in)

```

->

```

      [7] scratch:
      #x3,x5,x11,x19,x2,x8,x30#

```

BEGIN

```

      MAC INPUT_TO_S(INT n) = (l_input: in)

```

->

```

      (flag,STRING(n bit)): BIOP TRANSFORM_S.

```

#the multiplier outputs, fast adder code commented out#

```

      LET in_s= (INPUT_TO_S(input_exp)in)[2].

```

```

      x2=in_s CONC b'0',

```

```

      x8=in_s CONC b'000',

```

```

      x3 = ADD_S_ACTEL(in_s, x2,b'1).

```

```

      x5 = ADD_S_ACTEL(in_s,in_s CONC b'00',b'1 ).

```

```

      x11 = ADD_S_ACTEL(x3,x8,b'1),

```

```

      x19 = ADD_S_ACTEL(x3,in_s CONC b'0000',b'1),

```

```

x30=ADD_S_ACTEL(x11,x19,b'1).

LET subsignal = (x2,x8, x3,x5 ,x11,x19,x30).
OUTPUT ((S_TO_[input_exp+2] x3)[2],(S_TO_[input_exp+3] x5)[2],(S_TO_[input_exp+4] x11)[2],
        (S_TO_[input_exp+5] x19)[2],(S_TO_[input_exp+1] x2)[2],(S_TO_[input_exp+3] x8)[2],
        (S_TO_[input_exp+6] x30)[2])
END.
MAC INBUF(TYPE i) = (i:pad)
->
i: #y#pad.

MAC OBHS(TYPE i) = (i:d)
->
i: #pad#d.

FN CLKBUF = (bool:pad)
->
bool:pad.
#MAC SHIFT(INT p) = (STRING[scratch_exp]bit) -> STRING[scratch_exp+p]bit:BIOP SR_S[p].#

MAC ADD_S = (STRING[INT m]bit,STRING[INT n]bit)
->
STRING[IF m>=n THEN m+1 ELSE n+1 F]bit:
BIOP PLUS_S.

MAC INV[INT m] = (STRING[m]bit:a)
->
STRING[m]bit:BIOP NOT.

MAC NEG_S = (STRING[INT n]bit)
->

```

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STRING[n+1]bit:
BIOP NEGATE_S.

MAC_ADD_US = (STRING[INT m]bit, STRING[INT n]bit)

-> STRING[IF m>n THEN m+1 ELSE n+1]bit:
BIOP PLUS_US.

MAC_CARRY = (l_add:in)

-> STRING[1]bit: CASE in
OF add:b'0':
sub:b'1':

ESAC.

#actel adder macros#

#an emulation of a fast ACTEL 16 bit adder with active low carries#
FN FADD16 = (STRING[scratch_exp]bit: a b, STRING[1]bit: cinb)

-> (STRING[scratch_exp]bit, STRING[1]bit):
BEGIN
LET a_c = a CONC INV(1)cinb,
b_c = b CONC INV(1)cinb,
out = ADD_S(a_c, b_c).
OUTPUT(out[2..scratch_exp+1], INV(1)B_TO_S out[1])
END.

#actel 1 bit full adder with active low cin and cout#
MAC FA1B = (bit: ain bin cinb)

->

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```

(bit.bit):#cob,s#
BEGIN
  LET  a_c = B_TO_S ain CONC INV(1)B_TO_S cinb,
        b_c = B_TO_S bin CONC INV(1)B_TO_S cinb,
        out = ADD_US(a_c,b_c).
  OUTPUT(CAST(bit) INV(1) B_TO_S out(1), out(2))
END.

```

#the actel version of the ADD BIOP's#

```

MAC ADD_US_ACTEL = (STRING(INT m)bit:ain,STRING(INT n)bit:bin,bit:cinb)

```

->

```

STRING(IF m>=n THEN m+1 ELSE n+1 F)bit:

```

```

BEGIN

```

```

  MAKE (IF m>=n THEN m ELSE n F)FA1B:sum.

```

#unsigned nos so extend by 0#

```

  LET a_c = IF m>=n THEN ain ELSE ZERO(n-m)b"0" CONC ain F1,
        b_c = IF n>=m THEN bin ELSE ZERO(m-n)b"0" CONC bin F1.
  LET subsignal = sum.

```

```

#lsb#

```

```

JOIN  (a_c(IF m>=n THEN m ELSE n F))b_c(IF m>=n THEN m ELSE n F))cinb) ->sum(IF m>=n THEN m ELSE n F).

```

```

FOR INT j=1..(IF m>=n THEN m ELSE n F)-1

```

```

JOIN (a_c(IF m>=n THEN m ELSE n F)-j)b_c(IF m>=n THEN m ELSE n F)-j, sum((IF m>=n THEN m ELSE n F)-j+1))
>sum((IF m>=n THEN m ELSE n F)-j).

```

```

OUTPUT  CAST(STRING(IF m>=n THEN m+1 ELSE n+1 F)bit)
(INV(1) B_TO_S sum[1][1] CONC

```

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```
CAST{STRING{IF m>=n THEN m ELSE n Fj|bit} [INT j=1..IF m>=n THEN m ELSE n Fj] sum[j][2]}
```

```
END.
```

```
MAC ADD S_ACTEL = (STRING{INT m|bit:ain, STRING{INT n|bit:bin, bit:cinb)
```

```
->
```

```
STRING{IF m>=n THEN m+1 ELSE n+1 Fj|bit:
```

```
BEGIN
```

```
MAKE {IF m>=n THEN m ELSE n Fj|FA1B:sum.
```

```
#signed nos so sign extend #
```

```
LET a_c = IF m>=n THEN ain ELSE ALL_SAME(n-m)B_TO_S ain[1] CONC ain Fj,
```

```
b_c = IF m>=n THEN bin ELSE ALL_SAME(m-n)B_TO_S bin[1] CONC bin Fj.
```

```
LET subsignal = sum.
```

```
#lsb#
```

```
JOIN (a_c|IF m>=n THEN m ELSE n Fj), b_c|IF m>=n THEN m ELSE n Fj, cinb) ->sum{IF m>=n THEN m ELSE n Fj}.
```

```
FOR INT j=1..(IF m>=n THEN m ELSE n Fj) -1
```

```
JOIN (a_c|IF m>=n THEN m ELSE n Fj) -j, b_c|IF m>=n THEN m ELSE n Fj -j, sum{IF m>=n THEN m ELSE n Fj} -j+1X1}) ->sum{IF m>=n THEN m ELSE n Fj} -j}.
```

```
OUTPUT CAST{STRING{IF m>=n THEN m+1 ELSE n+1 Fj|bit}
```

```
{(INV(1) B_TO_S sum[1][1]) CONC
```

```
CAST{STRING{IF m>=n THEN m ELSE n Fj|bit} [INT j=1..IF m>=n THEN m ELSE n Fj] sum[j][2]}
```

```
END.
```

```
FN ROUND_BITS = (t_scratch.in, t_round: select)
```

```
->
```

```
t_input:
```

```
BEGIN
```

#THIS ASSUMES THAT THE INPUT_EXP=10!!!!#

#select chooses a round factor of 3, 4, 5#

#the lsb is the right hand of the string,#

#the index 1 of the string is the left hand end, & is the msb#

#so on add ops bit 1 is the carryout#

LET s1 = (I_TO_S[scratch_exp]in)/2).

msb= B_TO_S s1[1].

selector = CASE select #case conversion for MUX_3#

OF shift3:1,

shift4:2,

shift5:7

ESAC,

#needs to be a 16 bit output for the adder#

shift = MUX_3[STRING[scratch_exp]bit]((

msb CONC msb CONC msb CONC s1[1..scratch_exp-3],

msb CONC msb CONC msb CONC msb CONC s1[1..(scratch_exp-4)],

msb CONC msb CONC msb CONC msb CONC msb CONC s1[1..scratch_exp-5],

selector

).

#the carry to round, 1/2 value is rounded towards 0#

cs = CASE select

OF shift4: CASE msb

OF b*1": s1[scratch_exp-3], #neg no.#

b*0": CASE s1[scratch_exp-3..scratch_exp]

OF b*1000": b*0 #round down on 1/2 value#

ELSE s1[scratch_exp-3]

ESAC

```

ESAC,
shift3: CASE msb
  OF b'1': s1[scratch_exp-2], #neg no.#
  b'0': CASE s1[scratch_exp-2..scratch_exp]
    OF b'100': b'0 #round down on 1/2 value#
    ELSE s1[scratch_exp-2]
    ESAC
  ESAC,

shift5: CASE msb
  OF b'1': s1[scratch_exp-4], #neg no.#
  b'0': CASE s1[scratch_exp-4..scratch_exp]
    OF b'10000': b'0 #round down on 1/2 value#
    ELSE s1[scratch_exp-4]
    ESAC
  ESAC,

sum17 = ADD_US_ACTEL(B_TO_S cs, shift, b'1),
sum = sum17[2..scratch_exp+1],
#bit 1 is carry out, gives 16 bit sum#
subsignal = (cs, sum),
#ACTEL HACK#
soa = CASE sum[1]
  OF b'1': t, #saturate to -512#
  b'0': 1 #saturate to 512#
  ESAC,

ss1 = CASE selector
  OF 1: CASE sum[4..7] #these are the 5 msb's form the 13 bit word#
    OF (b'1111' | b'0000'): t #value in range#

```

```

ELSE I
ESAC,

c: CASE sum[5..7]#these are the 3 msb's from the 12 bit word left after#
    # taking out the 4 sign extension bits#
    OF (b'111' | b'000'): I #value in range#
    ELSE I
    ESAC,

r: CASE sum[6..7] #these are the 2 msb's from the 11 bit word#
    OF (b'11' | b'00'): I #value in range#
    ELSE I
        ESAC
    ESAC,
    out= MXT(STRING[scratch_exp-6]|| (b'0111111111' b'1000000000', sum[7..scratch_exp], soa, t, ss1).
    OUTPUT (S_TO_IN out)[2]
END.

MAC LINE_DELAY_ST(TYPE I)=[(4):in, I_col:wr_address, I_col:rd_address, I_load:rw)
->

RAM[(4)?I).
    [4]I:

FN PR_ADDER_ST = (I_scratch: a b )
->
    I_scratch:
    (S_TO_I[scratch_exp] ADD_S((I_TO_S[scratch_exp-1]a)[2], (I_TO_S[scratch_exp-1]b)[2])) [2].

FN ADD_SUB_ST = (I_scratch: a b, I_add: sel)
->

```


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```
l_scratch:
BEGIN
```

```
    LET a_s=(l_TO_S[scratch_exp]a)[2],
        b_s=(l_TO_S[scratch_exp]b)[2],
        sel_bit = CAST(STRING(1)bit)sel.
```

```
#ACTEL#
```

```
    b_s_inv = XOR_B[scratch_exp](b_s, ALL_SAME[scratch_exp]sel_bit).
```

```
#cintb is active low so cast sel(add->0,sub->1) & invert it#
```

```
    out= ADD_S_ACTEL(a_s,b_s_inv,CAST(bit)INV(1)sel_bit ).
    binout= out[2..scratch_exp+1].
```

```
    OUTPUT (S_TO_l[scratch_exp]binout)[2]
END.
```

```
MAC ALL_SAME(INT n) = (STRING(1)bit:dummy)
```

```
->
```

```
    STRING(n)bit:
```

```
    BEGIN
```

```
        FAULT IF n < 1 THEN "N<1 in ALL_SAME" FI.
```

```
        OUTPUT IF n=1 THEN dummy
```

```
        ELSE dummy CONC ALL_SAME[n-1] dummy
```

```
    FI
```

```
    END.
```

```
MAC CAST (TYPE to) = (TYPE from:in)
```

```
->
```

```
    lo:ALIEN CAST.
```

```

MAC_ZERO[INT n] = (STRING[1]bit:dummy)
->
STRING[n]bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ZERO" FI.
  OUTPUT IF n=1 THEN b"0"
    ELSE b"0" CONC ZERO[n-1] b"0"
    FI
  END.
MAC_B_TO_S = (bit:in)
->
  STRING[1]bit: CASE in
    OF b"0:b"0",
      b"1:b"1"
    ESAC.
MAC_I_TO_S[INT n] = (t_scratch: in)
->
  (flag,STRING[n]bit): BIOP_TRANSFORM_S.
MAC_S_TO_I[INT n] = (STRING[n]bit:in)
->
  (flag,t_scratch): BIOP_TRANSFORM_S.
MAC_S_TO_IN = (STRING[input_exp]bit:in)
->
  (flag,t_input): BIOP_TRANSFORM_S.
MAC_IN_TO_S[INT n] = (t_input: in)
->
  (flag,STRING[n]bit): BIOP_TRANSFORM_S.
MAC_U_TO_I[INT n] = (STRING[n]bit:in)
->

```

((flag,t_scratch): BIOP TRANSFORM_U.

MAC_B_TO_I = (bit:in)

->

t_scratch: CASE in

OF b'0:scratch/0,
b'1:scratch/1

ESAC.

MAC_CARRY = (t_add:in)

->

STRING[1]bit: CASE in

OF add:b'0",
sub:b'1"

ESAC.

MAC_BOOL_BIT = (bool:in)

->

STRING[1] bit:

CASE in

OF t:b'1"

ELSE b'0"

ESAC.

MAC_BIT_BOOL = (bit:in)

->

bool:

CASE in

OF b'11

ELSE 1

ESAC.

```

MAC BOOL_STRING(INT n) = ([n]bool.in)
->
STRING[n] bit:
(LET out = BOOL_BIT in[1].
OUTPUT IF n=1
THEN out
ELSE out[1] CONC BOOL_STRING[n-1](in[2..n])
FI
).

```

#define a few useful gates #

FN NOT = (bool:in) ->bool:

CASE in

OF t:1,

f:1

ESAC.

FN MUX = (bool:sel in1 in2) -> bool:

two input mux, select in1 if sel = 1, otherwise in2

CASE sel

OF t:in2,

f:in1

ESAC.

FN XNOR=(bool:in1 in2)->bool:

CASE (in1,in2)

OF (t,t)1,

(t,f)1,

(f,t)1,

(f,f)1

ESAC.

```

FN XOR=(bool:in1 in2) ->bool:
  CASE (in1,in2)
  OF
    (f,f):f,
    (f,t):t,
    (t,f):t,
    (t,t):f
  ESAC.

FN OR = (bool:in1 in2) ->bool:
  CASE (in1,in2)
  OF
    (t,bool)||((bool,t):t,
    (f,f) : f
  ESAC.

#FN MYLATCH = (bool:in) ->bool:DELAY(f,t).#

FN MYLATCH = (t_reset:reset,bool:in) ->bool:
BEGIN
  MAKE PDEL[bool,0]:del.
  LET out = CASE reset
    OF rst:f
    ELSE del
    ESAC.
  JOIN in->del.
  OUTPUT out
END.

TYPE t_test = NEW(no)yes).
#.....#
#These functions change types from boolean to inpuleger and vice-#
#versa. Supports 1 & 8 bit booleans.
#.....#

```

```

FN INT_BOOL=(t_input:k)    ->bool:      # 1bit input to binary #
CASE k
OF
  input/0:1,
  input/1:t
ESAC.

```

```

FN BOOL_INT=(bool:b) ->l_input:      # 1 bit bool to input #
CASE b
OF
  t:input/0,
  t:input/1
ESAC.

```

```

FN * =(t_input:a b)      ->l_input: ARITH a*b.
FN % =(t_input:a b)      ->l_input: ARITH a%b.
FN - =(t_input:a b)      ->l_input: ARITH a-b.
FN + =(t_input:a b)      ->l_input: ARITH a+b.
FN = =(t_input:a b)      ->l_test: ARITH IF a=b THEN 2 ELSE 1 FI.

```

```

COM
FN CHANGE_SIGN = (t_input:i) ->l_input:      #changes sign for 8-bit 2's#
ARITH IF i<0 THEN 128+i      #complement no, #
ELSE i
FI.

```

```

FN SIGN = (t_input:i) ->bool:      #gets sign for 2's#
ARITH IF i<0 THEN 1      #complement nos #
ELSE 2
FI.

```

```

FN TEST_SIZE = (t_input:x) ->bool:

```

```
#tests to see if the input is bigger than an 8-bit integer#
  ARITH IF ( (x<=-128) AND (x>127)) THEN 1
    ELSE 2    FI.
```

```
FN INT8_BOOL=(t_input:orig) ->[8]bool:
BEGIN
```

```
  SEQ
    VAR i1:=input/0,    #input variables#
        i0:=CHANGE_SIGN(orig),
        b:=(1,1,1,1,1,1,1,1,SIGN(orig));
    [(INT n=1..7) (
      i1:=i0%input/2;
      b[n]:=INT_BOOL(i0-input/2*i1);
      i0:=i1
    )];
    OUTPUT CASE TEST_SIZE orig    #checks to see if orig will#
      OF   t:    [8]?bool,    #fit input to an 8_bit value#
          f:    b
    ESAC
  END.
```

```
FN BOOL_INT8=([8]bool:b) ->t_input:    #converts 8bit boolean to 2's#
BEGIN
```

```
  SEQ
    VAR sum:=input/-128 * BOOL_INT(b[8]),    #complement integer #
        exp:=input/1;
    [(INT k=1..7) (
      sum:=sum+exp*BOOL_INT(b[k]);
      exp:=input/2 * exp
    )];
```

```

    );
    OUTPUT sum
END.

MOC
FN BOOL_INT10=([10]bool:b) ->t_input: #converts 10bit boolean to 2's#
BEGIN
    SEQ
    VAR sum:=input/-512*BOOL_INT(b[10]), #complement integer #
    exp:=input/1;
    [INT k=1..9]
    (
        sum:=sum+exp*BOOL_INT(b[k]);
        exp:=input/2*exp
    );
    OUTPUT sum
END.
COM
FN BOOL_INT16 =([8]bool:in1 in2) ->t_input:
# converts a 16-bit no., (lsbs,msbs) Input to Integer form)#
(BOOL_INT8(in1))+((input/256)*BOOL_INT8(in2))+((input/256)*BOOL_INT(in[8])).
#hack because of sign extend#
#of lsb #
MOC
#compute the mean square difference between two arrays of integers#
FN MSE_COLOUR = (t_reset:reset_input:a b) ->[2]t_int32:
BEGIN
    FN SAVE_ERROR = (t_reset:reset,t_int32:diff32) ->t_int32:
    BEGIN
        MAKE PDEL(t_int32,0) del,

```



```

PDEL(!_reset,0):edge.

LET rising = CASE (reset,edge)
  OF (no_rst,rst):diff32,
     (no_rst,no_rst):del PL diff32
  ELSE del
  ESAC.

JOIN rising ->del,
reset ->edge.

OUTPUT del
END.

MAKE SAVE_ERROR:save_error.
LET out = (SEQ
  STATE VAR true_count INIT int32/1;
  VAR diff:=int32/0,
  diff32:=int32/0,
  incr:=int32/0;

  diff:=CASE reset
    OF rst:int32/0
    ELSE !_32(a) MI !_32(b)
  ESAC;
  incr:=CASE reset
    OF rst:int32/0
    ELSE int32/1
  ESAC;
  true_count:= CASE reset
    OF rst:int32/1
    ELSE true_count PL incr
  ESAC;

```

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```

diff32:= (diff T1 diff);
OUTPUT (diff32,true_count) ).

```

```

JOIN      (reset,out(1))      -->save_error.
OUTPUT    (save_error,save_error DV out(2))
END.

```

#compute the mean square difference between two arrays of integers#

```

TYPE t_int32 = NEW int32/(-2147483000..2147483000).
INT period_row=9.

```

```

FN I_32 = (t_input:in)  ->t_int32:ARITH in.
FN DV = (t_int32:a b)   ->t_int32:ARITH a*b.
FN PL = (t_int32:a b)   ->t_int32:ARITH a+b.
FN MI = (t_int32:a b)   ->t_int32:ARITH a-b.
FN TI = (t_int32:a b)   ->t_int32:ARITH a*b.

```

```

FN MSE_ROW = (t_input:a b) ->t_int32:
BEGIN SEQ

```

```

    STATE VAR err INIT int32/0,
           count INIT int32/0;
    VAR diff:=int32/0,
        diff32:=int32/0;

```

```

    count:=count PL int32/1;

```

```

diff:=CASE count
  OF int32/(1..period_row):int32/0
  ELSE 1_32(a) MI 1_32(b)
  ESAC;
diff32:= (diff T1 diff);
err:=err PL diff32;
OUTPUT (err, err DV count,count)
END.

```

```

FN PRBS10 = (t_reset:reset) ->{10}bool:
#A 10 bit prbs generator,feedback taps on regs 3 & 10.#
BEGIN

```

```

  MAKE [10]MYLATCH:1,
  XNOR xnor.

```

```

  FOR INT k=1..9 JOIN

```

```

    (reset,[k]) ->{k+1}.

```

```

  JOIN (reset,xnor) ->{1}.

```

```

    ([10],[3]) ->xnor.

```

```

  OUTPUT 1

```

```

END.

```

```

FN PRBS11 = (t_reset:reset) ->{11}bool:
#A 11 bit prbs generator,feedback taps on regs 2 & 11.#
BEGIN

```

```

  MAKE [11]MYLATCH:1,
  XNOR xnor.

```

```

FOR INT k=1..10      JOIN
  (reset,[k])        ->[k+1].

JOIN  (reset,xnor)    ->[1].
      ([1],[2])       ->xnor.

OUTPUT  [1..10]

END.
COM
FN PRBS16 = (bool:reset) ->[16]bool:
#A 16 bit prbs generator,feedback taps on regs 1,3,12,16#
BEGIN
  MAKE [16]MYLATCH:1,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..15      JOIN
  (ck,reset,[k])     ->[k+1].

JOIN  (ck,reset,xnor) ->[1].
      ([1],[3],[16],[12]) ->xor,
      xor              ->xnor.
OUTPUT ([INT k=1..16][k])

END.
FN PRBS12 = (clock:ck,bool:reset) ->[12]bool:
#A 12 bit prbs generator,feedback taps on regs 1,4,6,12.#
BEGIN
  MAKE [12]MYLATCH:1,
  XOR_4:xor,
  NOT:xnor.

```

```

FOR INT k=1..11 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN (ck,reset,xnor) ->[1].
  ([1],[4],[6],[12]) ->xor,
  xor ->xnor.
OUTPUT ((INT k=1..12)[k])
END.

FN PRBS8 = (clock:ck,bool:reset) ->[8]bool:
#A 8 bit prbs generator,feedback taps on regs 2,3,4,8.#
BEGIN
  MAKE [8]MYLATCH1,
  XOR_4:xor,
  NOT:xnor.

FOR INT k=1..7 JOIN
  (ck,reset,[k]) ->[k+1].

JOIN (ck,reset,xnor) ->[1],
  ([2],[3],[4],[8]) ->xor,
  xor ->xnor.
OUTPUT ((INT k=1..8)[k])
END.

MOC
#TEST FOR Y U V #
#to test the 2d convolver using prbs input into the forward convolver#
#then outputting to the inverse convolver and checking against the original result#

```

```

FN TEST_COLOUR = (bool:ck,t_reset:reset,bool:extwrite| in csl_in, t_sparc_addr:reg_sel value,t_reset:prbs_reset)
->{3}t_in32:

```

```

BEGIN

```

```

    FN DEL = (t_load:in) ->t_load:DELAY(read,1).

```

```

    FN PULSE = (t_load:in) ->t_reset:

```

```

    CASE (in,DEL in)

```

```

    OF (write,read):rst

```

```

    ELSE no_rst

```

```

    ESAC.

```

```

    MAKE PRBS11:prbs,

```

```

    BOOL_INT10:int_bool,

```

```

    DWT:dwt,

```

```

    {3}MSE_COLOUR:mse_colour.

```

```

JOIN (CASE (prbs_reset,PULSE CASE dwt{3}[2]

```

```

    OF write:read,

```

```

    read:write

```

```

    ESAC,PULSE CASE dwt{3}[3]

```

```

    OF write:read,

```

```

    read:write

```

```

    ESAC,PULSE dwt{2}[1],PULSE dwt{2}[2],PULSE dwt{2}[3])

```

```

OF

```

```

    (rst,t_reset,t_reset,t_reset,t_reset,t_reset,rst,t_reset,t_reset,t_reset,t_reset,t_reset)

```

```

    (t_reset,t_reset,rst,t_reset,t_reset,t_reset,t_reset,t_reset,rst,t_reset,rst,t_reset)

```

```

    (t_reset,t_reset,t_reset,t_reset,rst,t_reset,t_reset,t_reset,rst,t_reset,rst,t_reset)

```

```

    ELSE no_rst

```

```

    ESAC)

```

```

->prbs,

```

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```

prbs      ->int_bool,
(ck,reset,int_bool,extwritel_in,csl_in,reg_sel,value)  ->dwt.

#calculate the mse error for each channel#
FOR INT j=1..3 JOIN
(CASE dwl[2][j])
OF read:rst
ELSE no_rst
ESAC,dwt[1],int_bool) ->mse_colour[j].
OUTPUT (mse_colour[1][1],mse_colour[2][1],mse_colour[3][1])
END.
FN DWT = (bool,t_reset,t_input,bool,bool,t_sparc_addr:reg_sel value) ->(t_input,[3],load,[3],load):IMPORT.
MAC PDEL(TYPE t, INT n) =() ->t:IMPORT.

IMPORTS      dwt/sining: DWT_TEST( RENAMED DWT) PDEL

#TEST FOR LUMINANCE ONLY#
#to test the 2d convolver using prbs input into the forward convolver#
#then outputting to the inverse convolver and checking against the original result#

FN TEST_Y = (bool:ck,t_reset:reset,bool:extwritel_in csl_in, t_sparc_addr:reg_sel value,t_reset:prbs_reset)
->[2],int32:

BEGIN
  FN DEL = (t_load:in) ->t_load:DELAY(read,1).
  FN PULSE = (t_load:in) ->t_reset:
  CASE (in,DEL in)

```

```

OF      (write,read):rst
ELSE no_rst
ESAC.

MAKE PRBS1:prbs,
BOOL_INT10:int_bool,
DWT:dwt,
MSE_COLOUR:mse_colour.

JOIN CASE (prbs_reset,PULSE dwf[2][1]) #rerun the prbs at start, or on out of IDWT#
OF      (rst,t_reset)/((t_reset,rst):rst
ELSE no_rst
ESAC)
->prbs,

prbs      ->int_bool,
(ck,reset,int_bool,extwrite1_in,cal_in,reg_sel,value) ->dwt,
(CASE dwf[2][1]
OF read:rst
ELSE no_rst
ESAC,dwf[1],int_bool) ->mse_colour.

OUTPUT mse_colour
END.
.
```


APPENDIX B-2

#test for abs #

FN ABS_TEST = (STRING[10]bit:in in2) -> bool: in LE_U in2.
 #the state machine to control the address counters#
 #only works for 3 octave decomposition in y/2 in ulv#

FN CONTROL_ENABLE = (bool:ck,t_reset:reset,t_channel:new_channel channel,[3]bootc_blk,STRING[2]bit:subband,
 t_load:load_channel,t_modernew_mode)

->([3]bool#en_blk#,t_octave,[2]bool#tree_done,lpf_block_done?,t_state#reset_state#):

BEGIN

MAKE DF1(t_state):state.

#set up initial state thro mux on reset, on HH stay in zz0 state#

LET start_state = CASE channel

OF ulv:down1,

y:up0

ESAC,

reset_state = CASE reset

OF rst: start_state

ELSE state

ESAC.

LET next_values = (SEQ

VAR en_blk=[3]t, #enable blk count#

lpf_block_done:=f, #enable x_count for LPF#

tree_done:=f, #enable x_count for other subbands#

new_state:=reset_state,

octave:=?t_octave; #current octave#

CASE reset_state

```

ELSE
  ESAC),
  zz1: ( octave:=oct0;
    en_blk(1):=t;
    CASE c_blk(1)
    OF  t(new_state:=zz2;
      en_blk(2):=t)
    ELSE
      ESAC),
    zz2: ( octave:=oct0;
      en_blk(1):=t;
      CASE c_blk(1)
      OF  t(new_state:=zz3;
        en_blk(2):=t)
      ELSE
        ESAC),
        zz3: ( octave:=oct0;
          en_blk(1):=t;
          CASE c_blk(1)
          OF  t(new_state:=down1;
            en_blk(2):=t; #roll over to 0#
            en_blk(3):=t  #because state zz3 clock 1 pulse#
          )
          ELSE
            ESAC
        ),
        down1: ( octave:=oct1;
          en_blk(2):=t;
          CASE o_blk(2)

```

#now decide the next state, on block(1) carry check the other block carries#

```

OFup0: ( octave:=oct/2;
  en_blk(3):=t;
  CASE c_blk(3)
  OF t:(CASE subband
    OF b"00":lpf_block_done:=t    #clock x_count for LPF y channel#
    ELSE new_state:=up1    #change state when count done#
    ESAC;
  CASE new_mode    #in luminance & done with that tree#
  OF stop:tree_done:=t
  ELSE
  ESAC)
  ELSE
  ESAC),
up1: ( octave:=oct/1;
  en_blk(2):=t;
  CASE c_blk(2)
  OF t:(new_state:=zz0;
  CASE new_mode    #in luminance, terminate branch & move to next branch#
  OF stop:(new_state:=down1;
    en_blk(3):=t)
  ELSE
  ESAC)
  ELSE
  ESAC),
zz0: ( octave:=oct/0;
  en_blk(1):=t;
  CASE c_blk(1)
  OF t:(new_state:=zz1;
    en_blk(2):=t)

```

```

OF t:(CASE subband
  OF b'00':lpf_block_done:=t    #clock x_count for LPF u/v channel#
  ELSE new_state:=zz0 #change state when count done#
ESAC;

```

```

CASE (new_mode,channel) #stop so finish this tree/branch & move on#
OF (stop,u/v):tree_done:=t,
  (stop,y):{en_blk[3]}:=t;
  CASE c_blk[3] #move to next tree#
  OF tree_done:=t
  ELSE new_state:=down1
  ESAC
)
ELSE
ESAC)
ELSE
ESAC)

```

```

ESAC;

```

```

CASE channel
OF u/v: CASE (c_blk[1],c_blk[2])
  OF (t,t):tree_done:=t
  ELSE
  ESAC,
  y: CASE (c_blk[1],c_blk[2],c_blk[3])
  OF (t,t,t):tree_done:=t
  ELSE
  ESAC

```

```

ESAC;

```

```

#now change to start state if the sequence has finished#
CASE tree_done #in LPF state doesnt change when block done#
OF: new_state:= start_state
ELSE
ESAC;
#on channel change, use starting state for new channel#
CASE load_channel #in LPF state doesnt change when block done#
OF write_new_state:= CASE new_channel
OFy:up0,
ulv:down1
ESAC
ELSE
ESAC;

OUTPUT (new_state,en_blk,octave,(tree_done,lpf_block_done))
).

JOIN (ck,next_values[1]) ->state.
OUTPUT (next_values[2],next_values[3],next_values[4],reset_state)
END.

FN CHECK = (t_inputx sub size y,t_octave: oct) ->t_sparc_addr:
ARITH ((x SL 1)+(1 IAND sub) + size*(y SL 1) +(sub SR 1)))SL oct.

#these are the addr gens for the x & y addresses of a pixel given the octave#
#sub&blk no. for each octave. Each x&y address is of the form #
# x= count(5 bits)(blk(3).blk(octave+1)){s} {octave 0's} #

```

```

# y= count(5 bits){blk(3)..blk(octave+1)}{s} {octave 0's} #
#this makes up the 9 bit address for CIF images #
#the blk & s counters are vertical 2 bit with the lsb in the x coord #
#and carry out on 3, last counter is both horiz and vertical counter #
#read_enable enable the block count for the read address, but not the #
#carry-outs for the mode change, this is done on the write addr cycle #
#by write_enable, so same address values generated on read & write cycles#

FN ADDR_GEN = (bool:ck, t_reset:reset, t_channel:new_channel_channel, t_load:load_channel, STRING[2]bit:sub_count,
STRING[xsize]bit:col_length, STRING[ysize]bit:row_length, STRING[xsize]bit:ximage_string,
STRING[ysize]bit:yimage_string, STRING[1]bit:yimage_string_3#yimage*2.5#,
bool:read_enable_write_enable, t_mode:new_mode)

-> (t_sparc_addr, t_octave, bool#sub_finished#, bool#tree_done#, bool#lpf_done#, t_state):
BEGIN
    MAKECOUNTER(xsize-4):x_count,
    COUNTER(ysize-4):y_count,
    CONTROL_ENABLE:control,
    [3]BLK_SUB_COUNT:blk_count.

#size of lpf images/2 -1, for y,uv. /2 because count in pairs of lpf values #
#lpf same size for all channels!!!#

LET (x_lpf, y_lpf) = (col_length[1..xsize-4], row_length[1..ysize-4]),

tree_done = control[3][1],
lpf_block_done = control[3][2],
x_en = CASE (tree_done, lpf_block_done)
    OF (t, bool) [(bod, 1):1
    ELSE 1
    ESAC,

```

```
blk_en=control[1],
octave=control[2],
```

#clk_y_count when all blocks done for subs 1-3, or when final blk done for lpf#

```
y_en = CASE sub_count
  OF b'00': CASE (lpf_block_done, x_count[2])
    OF (1,1):
      ELSE f
    ESAC
  ELSE CASE (tree_done, x_count[2])
    OF (1,1):
      ELSE f
    ESAC
  ESAC,
```

```
x_msb_out = CASE channel
  OF y: x_count[1] CONC B TO S(blk_count[3][1][2]), #always the msb bits#
    ulv: b'0' CONC x_count[1]
  ESAC,
```

```
y_msb_out = CASE channel
  OF y: y_count[1] CONC B TO S(blk_count[3][1][1]),
    ulv: b'0' CONC y_count[1]
  ESAC,
```

```
x_lsb_out = CASE (octave) #bit2 is lsb#
  OF (oct0): ((INT k=1..2) blk_count[3-k][1][2]) CONC sub_count[2],
    (oct1): (blk_count[2][1][2], sub_count[2], b'0),
    (oct2): sub_count[2] CONC [2]b'0
  ESAC,
```


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```

y_lsb_out = CASE (octave) #bit 1 is msb#
OF (oct0):(INT k=1..2)blk_count[3-k][1][1]CONC sub_count[1],
  (oct/1):(blk_count[2][1][1], sub_count[1], b'0),
  (oct/2):sub_count[1] CONC [2]b'0
ESAC,
x_addr = x_msb_out CONC BIT_STRING[3]x_lsb_out,
y_addr = y_msb_out CONC BIT_STRING[3]y_lsb_out,

```

```

#enable the sub band counter#

```

```

sub_en = CASE (y_count[2],y_en)
OF (t..1):
ELSE f
ESAC,

```

```

lpf_done = CASE sub_count
OF b'00':sub_en
ELSE f
ESAC,
#IIIICHANGE ACCORDING TO LATENCY IN DECODE#

```

```

base_y_sel = CASE channel
OF y1,
  uc,
  vt
ESAC,

```

```

base_rows = MUX_3(STRING[1]b'1'(ZERO[1]b'0'.b'0' CONC yimage_string[1..ysize]CONC b'0',
  yimage_string_3,base_y_sel),
#base address for no of rows for y,u & v memory areas#

```

```

address = x_addr ADD_U ((y_addr ADD_U base_rows)[2..12]) MULT_U (CASE channel
OF y:image_string,

```

```

        u[y:(SR_U(1)ximage_string)[1.xsize]
        ESAC)
    ),
    int_addr = (S_TO_SPARC address)[2].

JOIN  (ck,reset,x_en,x_lpf)    -->x_count,
      (ck,reset,y_en,y_lpf)    -->y_count,
      #use new_channel so on channel change control state picks up correct value#
      (ck,reset,new_channel,channel,((INT [1..3]blk_count)[2]),sub_count,load_channel,new_mode)
      -->control.
FOR INT k=1..3 JOIN  (ck,reset,blk_en[k],read_enable OR write_enable,write_enable) -->blk_count[k].

OUTPUT (int_addr,octave,sub_en,tree_done,lpf_done,control[4])
END.

#a counter to control the sequencing of r/w, token, huffman cycles#
#decide reset is enabled 1 cycle early, and latched to avoid glitches#
#lpf_stop is a dummy mode to disable the block writes&huffman data#
#cycles for that block#

FN CONTROL_COUNTER = (bool:ck.t_reset:reset.t_mode:mode new_mode.t_direction:direction)
-->(t_load,t_cycle,t_reset,bool:load.t_cs.t_load.t_cs):

#mode load,cycle,decide reset,read_addr_enable,write_addr_enable,load flags#
#decode write_addr_enable early and latch to avoid feedback loop with pro_mode#
#in MODE_CONTROL#
BEGIN
    MAKE COUNT_SYNC(4):count.

```

```
LET count_len = (U_TO_LEN(4) count[1])[2].
```

```
LET out = (SEQ
```

```
VAR cycle:=skip_cycle,
  decide_reset:=no_rst,
  load_mode:=read,
  load_flags:=read,
  cs_new:=no_select,
  cs_old:=select,
  rw_old:=read,
  read_addr_enable:=f,
  write_addr_enable:=f,
```

```
CASE direction
```

```
OF forward: CASE mode
```

```
  OF send|still_send|pf_send: CASE count_len
    OF len/(0..3): (read_addr_enable:=f;
                     cs_new:=select),
    len/(4): (cycle:=token_cycle;
               load_flags:=write;
               write_addr_enable:=f),
```

```
len/(5..7): (write_addr_enable:=f;
```

```
  CASE new_mode
```

```
  OF stop|pf_stop: (cycle:=skip_cycle;
```

```
    rw_old:=read;
```

```
    cs_old:=no_select),
```

```
  vold: (cycle:=skip_cycle;
```

```
    rw_old:=write)
```

```
  ELSE (cycle:=data_cycle;
```

```
    rw_old:=write)
```

```

    ESAC),
    len/8:(decide_reset:=rst;
    CASE new_mode
      OF stop|pf_stop:(cycle:=skip_cycle;
        rw_old:=read;
        cs_old:=no_select);
      void:(cycle:=skip_cycle;
        load_mode:=write;
        rw_old:=write)
      ELSE (cycle:=data_cycle;
        load_mode:=write;
        rw_old:=write)
      ESAC)
    ELSE
    ESAC,
    still: CASE count_len
      OF len/(0..3):(read_addr_enable:=t;
        cs_new:=select);
        len/(4):(cycle:=token_cycle;
        write_addr_enable:=t;
        load_flags:=write);
        len/(5..7):(rw_old:=write;
        write_addr_enable:=t;
        CASE new_mode
          OF void_still:(cycle:=skip_cycle
          ELSE cycle:=data_cycle
          ESAC),
        len/8:(decide_reset:=rst;

```

```

rw_old:=write;
load_mode:=write;
CASE new_mode
OF void still:cycle:=skip_cycle
ELSE cycle:=data_cycle
ESAC)

```

```

ELSE
ESAC,

```

```

tpf_still: CASE count len
OF len/(0..3):(read_addr_enable:=t;
               cs_new:=select);
len/(4):(cycle:=token_cycle;
          write_addr_enable:=t;
          load_flags:=write);
len/(5..7):(cycle:=data_cycle;
            rw_old:=write;
            write_addr_enable:=f);
len/8:(cycle:=data_cycle;
       rw_old:=write;
       decide_reset:=rst;
       load_mode:=write)
ELSE
ESAC,

```

```

void: CASE count len
      OF len/(0..3):(read_addr_enable:=t;
                     cs_new:=select);
len/4:(load_flags:=write;
       cycle:=token_cycle; #dummy token cycle for mode update#

```

```

write_addr_enable:=t),
  len/5..7:(write_addr_enable:=t; #keep counters going#
CASE new_mode
  OF stop:(rw_old:=read;
    cs_old:=no_select)
  ELSE rw_old:=write
    ESAC),
  len/8:(decide_reset:=rst;
CASE new_mode
  OF stop:(rw_old:=read;
    cs_old:=no_select)
  ELSE (load_mode:=write;
    rw_old:=write)
    ESAC)

```

```

ELSE
ESAC,

```

```

void_still: CASE count_len
  OF len/0: write_addr_enable:=t, #allow for delay#
  len/1..3:(write_addr_enable:=t;
    rw_old:=write),
    len/4:(rw_old:=write;
      load_mode:=write;
decide_reset:=rst)
  ELSE
  ESAC

```

```

ELSE
ESAC,

```

Inverse: CASE mode

```

OF send|still_send|pf_send: CASE count_len
  OF len/(0..3):(read_addr_enable:=t),
    len/(4):(cycle:=token_cycle;
      write_addr_enable:=t;
      load_flags:=write);
    len/(5..7):(write_addr_enable:=t;
      CASE new_mode
        OF stop|pf_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select);
          void:(cycle:=skip_cycle;
            rw_old:=write)
        ELSE (cycle:=data_cycle;
          rw_old:=write)
          ESAC);
    len/8:(decide_reset:=rsi;
      CASE new_mode
        OF stop|pf_stop:(cycle:=skip_cycle;
          rw_old:=read;
          cs_old:=no_select);
          void:(cycle:=skip_cycle;
            load_mode:=write;
            rw_old:=write)
          ELSE (cycle:=data_cycle;
            load_mode:=write;
            rw_old:=write)
          ESAC)
      ELSE
        ESAC,

```

```

still:  CASE count_len
        OF len/0);,      #skip to allow reset in Huffman#
        len/1):(cycle:=token_cycle;
            write_addr_enable:=1),
        len/2..4):(rw_old:=write;
            write_addr_enable:=1;

        CASE new_mode
        OF void_still_cycle:=skip_cycle
        ELSE cycle:=data_cycle
        ESAC),

        len/5:(rw_old:=write;
            decide_reset:=rst;
            load_mode:=write;
            CASE new_mode
            OF void_still_cycle:=skip_cycle
            ELSE cycle:=data_cycle
            ESAC)

        ELSE
        ESAC,
        bpf_still: CASE count_len
        OF len/0);,      #match with previous#
        len/1):(
            #skip for write enable delay#
            write_addr_enable:=1),
            len/2..4):(cycle:=data_cycle;
                rw_old:=write;
                write_addr_enable:=1),
            len/5:(cycle:=data_cycle;
                rw_old:=write;
                decide_reset:=rst;
                load_mode:=write)

```



```

ELSE
ESAC,
CASE count_len
OF len/0..3:(read_addr_enable:=t),
   len/4:(load_flags:=write;
   cycle:=token_cycle; #dummy token cycle for mode update#
   write_addr_enable:=t),
   len/5..7:(write_addr_enable:=t;
CASE new_mode
  OF stop:(rw_old:=read;
            cs_old:=no_select)
   ELSE rw_old:=write
   ESAC),
len/8:(decide_reset:=rst;
CASE new_mode
  OF stop:(rw_old:=read;
            cs_old:=no_select)
   ELSE (load_mode:=write;
         rw_old:=write)
   ESAC)

ELSE
ESAC,
CASE count_len
  OF len/0:., #match with reset#
   len/1:write_addr_enable:=t, #dummy as write delayed#
   len/2..4:(write_addr_enable:=t;
             rw_old:=write),
   len/5: (rw_old:=write;
           load_mode:=write;
           decide_reset:=rst)
   ELSE

```

void_still:

```

        ELSE
        ESAC

    ESAC;

    OUTPUT (load_mode,cycle,DF1(!_reset){ck,decide_reset},read_addr_enable,
    DFF{bool}{ck,reset,write_addr_enable,!},load_flags,
    cs_new,rw_old,cs_old)
    ).

    JOIN (ck,CASE reset
    OF rstreset
    ELSE out[3]
    ESAC,! ) ->count.

    OUTPUT out
    END.

    #.....#
    #A set of boolean ,ie gate level counters          #
    #.....#

    #.....#
    #The basic toggle flip-flop plus and gate for a synchronous counter #
    #input t is the toggle ,outputs are q and tc (toggle for next counter)#
    #stage                                             #
    #.....#

    MAC BASIC_COUNT = (bool:ck ,!_reset:reset,bool: tog) ->(STRING[1]bit,bool):

```

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```

BEGIN
  MAKE DFF{bool}:dlat,
  XOR :xor,
  AND :and.

  JOIN (ck,reset,xor,f)->dlat,
    (dlat,tog) ->and,
    (tog,dlat) ->xor.
  OUTPUT (CAST{STRING{1}bit} dlat,and)

END.

#.....#
# The n-bit macro counter generator, en is the enable, the outputs #
# are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
#.....#

MAC COUNT_SYNC{INT n} = (boot:ck,t_reset: reset,boot: en )->(STRING{n}bit,bool):
(LET out = BASIC_COUNT(ck,reset,en) .

  OUTPUT ( IF n=1
    THEN {out{1},out{2}}
    ELSE ( LET outn = COUNT_SYNC{n-1}(ck,reset,out{2}) .
      OUTPUT {outn{1} CONC out{1},outn{2}}
    )
  FI)

).
COM
FN TEST_COUNT_SYNC = (boot:ck,t_reset: reset,boot: en ) ->({4}bool,bool):
COUNT_SYNC{4}(ck,reset,en).
MOC

```

```

# .....#
#The basic toggle flip-flop plus and gate for a synchronous counter #
#input t is the toggle, updown delims the direction ,outputs are q and #
# tc (toggle for next counterstage, active low for down/high for up) #
# .....#

```

```

MAC BASIC_COUNT_UD = (bool:ck ,t_reset:reset,bool: tog, t_updown:updown) ->[2]bool:

```

```

BEGIN
    MAKE DFF(bool):dlat.
    LET toggle = tog.
    xorn = CASE updown
    OF up: CASE (toggle,dlat) #xor#
    OF (t,t)|(f,f):f
    ELSE f
    ESAC,
    down:CASE (toggle,dlat) #xnor#
    OF (t,t)|(f,f):f
    ELSE f
    ESAC
    ESAC,
    cout = CASE updown
    OF up:CASE (dlat,toggle) #AND#
    OF (t,t):f
    ELSE f
    ESAC,
    down:CASE (dlat,toggle) #OR#
    OF (f,f):f
    ELSE f
    ESAC

```

ESAC.

JOIN (ck,reset,xorn,f)->diat.
OUTPUT (diat,count)

END.

.....#
The n-bit macro u/d counter generator, en is the enable, the outputs #
are msb(bit 1).....lsb,carry. This is the same order as ELLA strings are stored#
#first enable is active low on down, so invert. #
.....#
MAC COUNT_SYNC_UD(INT n) = (boot:ck,t_reset: reset,boot:en,t_updown:updown) ->(STRING(n)bit,bool):
BEGIN

MAKE [n]BASIC_COUNT_UD:basic count.

LET enable = ((INT k=1..n-1) basic_count[k+1][2]) CONC CASE updown #invert enable if down count#

OF up:en

ELSE NOT en

ESAC.

FOR INT k=1..n JOIN (ck,reset,enable[k],updown) ->basic_count[k].

OUTPUT (BOOL_STRING(n)((INT k=1..n)basic_count[k][1]), basic_count[1][2])

END.

COM

FN TEST_COUNT_SYNC_UD = (boot:ck,t_reset: reset,boot:en,t_updown:updown) ->([4]bool,bool):
COUNT_SYNC_UD(4)(ck,reset,en,updown).

MOC

#the basic x/y counter, carry out 1 cycle before final count given by x_lpf/y_lpf#
MAC COUNTER(INT n) = (boot:ck,t_reset:reset,boot:en,STRING(n)bitx_lpf) ->(STRING(n)bit,bool):
BEGIN

```

MAKE COUNT_SYNC(n):x_count.

LET out = x_count[1].
final_count = out EQ_U x_lpf,
final_count_en=CASE (final_count,en)
  OF (f,f):f
  ELSE f
  ESAC,
#reset after 4 counts at final count value#
cnt_reset = CASE reset
  OF rst:rst
  ELSE CASE DF1(bool)(ck,final_count_en) #reset taken out of DFF 12/6#
    OF rst
    ELSE no_rst
    ESAC
  ESAC.
JOIN (ck,cnt_reset,en) ->x_count.
OUTPUT (out,final_count)
END.
COM
#the basic y counter, carry out 1 cycle before final count given by y_lpf#
#reset at end of channel given by system reset #
MAC Y_COUNTER = (boot:ck,reset:reset,boot:en,STRING(4)bit:y_lpf) ->(STRING(4)bit,bool):
BEGIN

MAKE COUNT_SYNC(4):y_count.

LET out = y_count[1].
JOIN (ck,reset,en) ->y_count.
OUTPUT (out,out EQ_U y_lpf)

```

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END.
MOC

```
COM
#the blk, or sub-band counters, carry out on 3#
FN BLK_SUB_COUNT = (bool:ck,1_reset:reset, bool:en)    ->(STRING[2]bit,bool):
BEGIN
  MAKE COUNT_SYNC[2]:blk_count.
  LET out = blk_count[1].
  JOIN (ck,reset,en) ->blk_count.
  OUTPUT(out,out EQ_U (C_TO_S[2]col[3])[2])
END.
MOC
```

```
#the blk, or sub-band counters, carry out on 3, cout_en enables the carry out, & cin_en AND en enables the count#
FN BLK_SUB_COUNT = (bool:ck,1_reset:reset, bool:en cin_en cout_en)    ->(STRING[2]bit,bool):
BEGIN
  MAKE COUNT_SYNC[2]:blk_count.
  LET out = blk_count[1].
  JOIN (ck,reset,en AND cin_en) ->blk_count.
  OUTPUT(out,(out EQ_U (C_TO_S[2]col[3])[2]) AND cout_en)
END.
```

```
FN LAST_BLK_COUNT = (bool:ck,1_reset:reset, bool:en,1_channel:channel,bool:line_finished) ->
  (STRING[2]bit,[2]bool:fx_en,y_en):
BEGIN
  MAKE BASIC_COUNT : lsb msb.
  JOIN (ck,reset,en) ->lsb,
  (ck,reset, CASE channel
```

```

OF y:lsb[2],
  u/v:line_finished
  ESAC) ->msb.
LET out = (msb[1]CONC[lsb[1]]).
OUTPUT (out, CASE channel
  OF y:(out EQ_U (C_TO_S[2]col[3])[2],line_finished).
    u/v:(lsb[2],msb[2])
    ESAC)
  END.
#the L1 norm calculator/ comparison constants& flag values#
#adding 4 absolute data values so result can grow by 2 bits#
#5 cycle sequence, a reset cycle with no data input, followed#
#by 4 data cycles#
MAC L1NORM = (bool:ck, l_reset:reset, STRING(INT n)bit:in) ->STRING[n+2]bit:
BEGIN
  MAKE DF1(STRING[n+4]bit):in2.

  LET in_s = in,
    msb = ALL_SAME(n)(B_TO_Sin_s[1]),
  COM
    add_in1 = in2 CONC in_s[1], #in_s[1] is the carryin to the addend#
    #lsb so gen carry to next bit#
    add_in2 = ((in_s XOR_B msb)CONC in_s[1]),
    #adder=ADD_U(add_in1,add_in2),#
  MOC
    add_in1 = (in_s XOR_B msb),
    rst_mux = CASE reset
      OF rst:ZERO(n+4)b"0"
      ELSE in2

```



```

ESAC,
adder=ADD_US_ACTEL(add_in1,rst_mux,CASE in_s[1]
  OF b'1:b'0
  ELSE b'1
  ESAC),
out =adder[2..(n+5)].

JOIN (ck,out) ->in2.

OUTPUT in2[3..n+4]
END.

#the block to decide if all its inputs are all 0#
FN ALL_ZERO = (bool:ck, t_reset:reset, t_input:in) ->bool:
BEGIN
  MAKE DF1(bool):out.

  LET in_s = (IN TO S(input_exp)in)[2],

  in_eq_0 = in_s EQ_U ZERO(input_exp)b'0", #in = 0#
  #1 if reset high, & OR with previous flag#
  all_eq_0 = CASE reset
    OF rst: in_eq_0
    ELSE CASE out
      OF t#
      ELSE in_eq_0
    ESAC
  ESAC.

```

```

JOIN (ck,all_eq_0)->out.
OUTPUT out
END.

```

```

MAC ABS_NORM = (bool:ck, t_reset:reset.STRING(result exp-2]bit:qshift, STRING(INT n]bit:in)
->(STRING[n+2]bit,bool#all <qshift#):

```

```

BEGIN
  MAKE DF1(STRING[n+4]bit]:in2,
  DF1{bool}:out.
  LET abs_in = ABS_S in,
  rst_mux = CASE reset
    OF rst:ZERO(n+4]b'0"
    ELSE in2
    ESAC,

```

```

  adder = ADD_US_ACTEL(abs_in,rst_mux,b'1),
  add_s = adder[2...(n+5)],
  in_small = abs_in LT_U qshift,
  #1 if reset high, & OR with previous flag#
  all_small = CASE reset
    OF rst: t
    ELSE CASE in_small
    OF ff
    ELSE out
    ESAC
    ESAC.

```

```

JOIN (ck,add_s) ->in2,
(ck,all_small) ->out.

```

```

OUTPUT (in2[3..n+4],out)

```

END.

```
#the decide fn block#
FN DECIDE = (bool:ck,t_1 resetreset,t_1 result:q int,t_1 input:new old,t_1 result: threshold comparison,
            t_1 octave:octs,t_1 load:load_flags) ->[7]bool:
#nzflag,origin,noflag,ozflag,motion,pro_new_z,pro_no_z#
BEGIN
    MAKE1NORM(input_exp): oz,
    ABS_NORM(input_exp): nz,
    ABS_NORM(input_exp+1):no,
    LATCH([7]bool):flags.
    LET qshift=(1 TO SC(result_exp[q_int])[2])[1..result_exp-2],
    #divide by 4 as test is on coeff values not block values#
    n_o=(1N TO S(input_exp)new)[2] SUB S (1N TO S(input_exp)old)[2], #new-old,use from quant#
    nzflag = nz[1] LE_U (1 TO SC(result_exp){threshold})[2], #delay tests for pipelined data#
    noflag = no[1] LE_U (1 TO SC(result_exp){comparison})[2],
    ozflag = oz EQ_U ZERO(input_exp)b'0',
    origin = nz[1] LE_U no[1],
    nz_plus_oz = nz[1] ADD_U oz,
    pro_new_z = nz[2],
    pro_no_z = no[2],
    shift_add_sel = CASE DF-1(t_1 octave)(ck,octs)
    OF
    oct/octno,
    #delay octs to match pipelin delay#
```

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```

oct/1: dos,
oct/2: tres,
oct/3: quatro
ESAC,
#keep 13 bits here to match no, keep msb's#
shift_add= MUX_4{STRING(input_exp+3)bit}(      #delay octs to match pipelin delay#
    nz_plus_oz[1..input_exp+3],
    b'0'CONC nz_plus_oz[1..input_exp+2],
    b'00'CONC nz_plus_oz[1..input_exp+1],
    b'000'CONC nz_plus_oz[1..input_exp],
    shift_add_sel
),
motion = shift_add LE_U no[1],
#value for simulation#
nz_r = (SC_TO_I[12] nz[1])[2],
no_r = (SC_TO_I[13] no[1])[2],
oz_r = (SC_TO_I[12] oz[2]),
sa_r = (SC_TO_I[13] shift_add)[2].

JOIN (ck,reset,qshift,(IN_TO_S(input_exp)new)[2]) ->nz,
      (load_flags,(nzflag,origin,noflag,ozflag,motion,pro_new_z,pro_no_z)) ->flags,
      (ck,reset,qshift,CAST{ STRING(input_exp+1)bit(n_o)} ->no,
      (ck,reset,(IN_TO_S(input_exp)old)[2]) ->oz.
OUTPUT flags
END.
#the buffer for the FIFO#

#a pulse generator, glitch free#
FN PULSE = (bod:ck,t_resetreset,t_load:in) ->t_load:

```

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```

CASE (in_DFF[i_load]{ck,reset,in,read})
OF (write,read):write
ELSE read
ESAC.

#the length of the huffman encoded word#
FN LENGTH = (i_input:mag_out) ->STRING[5]bit;
CASE mag_out #length of inputoded word#
OF input/0:b"00001",
input/1:b"00011",
input/2:b"00100",
input/3:b"00101",
input/4:b"00110",
input/5:b"00111",
input/6:b"01000",
input/(7..21):b"01100"
ELSE b"10000"
# input/(22..37):b"10000"#
ESAC.

FN REV_BITS = (STRING[8]bit:in) ->STRING[8]bit:CAST(STRING[8]bit)(n[8],n[7],n[6],n[5],n[4],n[3],n[2],n[1]).

FN FIFO_BUFFER = (bootck,i_reset:reset,i_direction:direction,i_cycle:cycle,i_mode:mode,
i_input:value mag_out_huff, STRING[16]bit:fifo_in,i_fifo:fifo_full fifo_empty,
STRING[32]bit:shift,STRING[2]bit:token_length, boot:flush_buffer,i_quant:ipf_quant)
->(STRING[16]bit,STRING[16]bit,STRING[16]bit,STRING[5]bit,i_load,i_load);
#fifo_out, s, fifo_read fifo_write#

BEGIN
MAKEDFF_INIT(STRING[16]bit):low_word high_word,

```

```

DFF_INIT(STRING[5bit]):s,
DFF_INIT(1:high_low:high_low,
MUX_2(STRING[16bit]:high_in_low_in_high_out_low_out.

```

```

LET dir_sel = CASE direction
                OF forward:left
                ELSE right
                ESAC,

```

```

length = CASE cycle
            OF token_cycle:b"000" CONC token_length,
               skip_cycle:b"00000",
               data_cycle: CASE mode #on LPF_STILL length fixed, given by input_exp-shift const#
                           OF 1:pf_still:(1:LEN TO U[5] len/input_exp)[2] SUB_U
                             (Q TO U[3] 1:pf_quant)[2][2..6]
                           ELSE LENGTH_MUX_2(1:input)(value, mag_out_huff, dir_sel)
                           ESAC
            ESAC,

```

```

selected_s = CASE direction
              OF forward:b"0" CONC s[2..5]
              ELSE s
              ESAC,

```

```

new_s = (ADD_US_ACTEL(selected_s, length, b"1"))[2..6], #6 bits#
#if new_s pointer > 16#
#on Inverse passed first 16 bits, active from [16,31] #

```

```

high_low_flag = new_s GE_U b"10000".

```

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```

#forward#
fifo_not_full = CASE fifo_full
  OF ok_fifo: write
  ELSE read
  ESAC,

fifo_write = CASE high_low #type change#
  OF high: write
  ELSE CASE flush_buffer #flush buffer when frame finished#
    OF twrite #needs 2 cycles to clear#
    ELSE CASE DFF[bool](ck, reset, flush_buffer, i)
      OF twrite
      ELSE read
      ESAC
    ESAC
  ESAC,
#from inverse#

data_ready = CASE fifo_empty
  OF ok_fifo: write
  ELSE read
  ESAC,

load_low = CASE reset #load low on reset to start things#
  OF rst: write,
  no_rst: PULSE(ck, reset, CASE (high_low_flag, data_ready) #load low word#
    OF (i, write): write
    ELSE read
    ESAC)

```

```

ELSE read
ESAC,
#delay reset for s and load_high#
reset_s = DFF(!_reset){ck,reset,reset,rst},

load_high =CASE reset_s #load high next#
OF
rstwrite,
no_rst: PULSE(ck,reset, CASE (high_low_flag,data_ready) #load high word#
OF (!,write):write
ELSE read
ESAC)
ELSE read
ESAC,

fifo_read = CASE load_low #read control for data_in FIFO#
OF write:read
ELSE CASE load_high
OF write:read
ELSE write
ESAC
ESAC,

#control signals#

(write_low,write_high) =CASE direction
OF forward:[2]fifo_not_full
ELSE (load_low,load_high)
ESAC,

(high_out_sel,low_out_sel) = CASE direction
OF forward:CASE high_low

```


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OF high:(left,right)
 ELSE (right,left)
 ESAC

ELSE [2]CAST(r_mux(s GE_U b'10000')
 ESAC.

JOIN

(shift[17..32],fifo_in,dir_sel) ->high_in,
 (shift[1..16],fifo_in,dir_sel) ->low_in,
 (high_word,low_word,high_out_sel) ->high_out,
 (low_word,high_word,low_out_sel) ->low_out,
 (ck,reset,write_low,low_in,ZERO[16]b'0') ->low_word,
 (ck,reset,write_high,high_in,ZERO[16]b'0') ->high_word,
 (ck,reset,fifo_not_full,CASE high_low_flag
 OF t:high
 ELSE low
 ESAC,low) ->high_low,
 (ck,CASE forward
 OF forward:reset
 ELSE reset_s
 ESAC,CASE direction
 OF forward:fifo_not_full

```

ELSE data_ready
ESAC, new_s, ZERO[5]b'0') ->s.

```

```

OUTPUT (low_word, low_out, high_out, s, ffo_read, ffo_write)
END.

```

```

#the HUFFMAN decode/encode function#

```

```

#a pulse generator, glitch free#

```

```

FN PULSE = (bool:ck, t, reset:reset, t_load:in) -> t_load:
CASE (in, DFF(t_load)(ck, reset, in, read))
OF (write, read):write
ELSE read
ESAC.

```

```

FN SHIFT32_16 = (STRING[32]bit:buffer, STRING[5]bit:s) -> STRING[16]bit:

```

```

#left justified value, s shift const#

```

```

BEGIN

```

```

LET shift = (s AND_B b'01111')[2..5]. #input values rotated so always shift<16#

```

```

OUTPUT

```

```

CAST(STRING[16]bit)(INT j=1..16] MX16(CAST(STRING[16]bit)(INT i=1..16]buffer[j-1+i], shift) )

```

```

END.

```

```

FN SHIFT16X16_32 = (STRING[16]bit:co n, STRING[4]bit:sel) -> STRING[32]bit:

```

```

BEGIN

```

```

LET sel_mux4 = CASE sel[1..2]

```

```

OF b'00':sel[3..4]

```

```

ELSE b'11'

```

```

ESAC,
sel_mux4_high = CASE sel[1..2]
  OF b'11"sel[3..4]
  ELSE b'00"
  ESAC,
sel_mux8 = CASE sel[1]
  OF b'0: sel[2..4]
  ELSE b'11"
  ESAC,
sel_mux8_high = CASE sel[1]
  OF b'1: sel[2..4]
  ELSE b'00"
  ESAC,
OUTPUT CAST(STRING(32)bit)(
  MX_4[bit](n[1],o[1],o[1],o[1],CAST[2]boolsel_mux4),
  MX_4[bit](n[2],n[1],o[2],o[2],CAST[2]boolsel_mux4),
  MX_4[bit](n[3],n[2],n[1],o[3],CAST[2]boolsel_mux4),
  MUX_8[bit](n[4],n[3],n[2],n[1],o[4],o[4],o[4],CAST[3]boolsel_mux8),
  MUX_8[bit](n[5],n[4],n[3],n[2],n[1],o[5],o[5],o[5],CAST[3]boolsel_mux8),
  MUX_8[bit](n[6],n[5],n[4],n[3],n[2],n[1],o[6],o[6],o[6],CAST[3]boolsel_mux8),
  MUX_8[bit](n[7],n[6],n[5],n[4],n[3],n[2],n[1],o[7],CAST[3]boolsel_mux8),
  MX16(CAST(STRING(8)bit)((INT I=1..8)n[9..I]) CONC ALL SAME(8)B TO S o[8],sel[1..4]),
  MX16(CAST(STRING(9)bit)((INT I=1..9)n[10..I]) CONC ALL SAME(7)B TO S o[9],sel[1..4]),
  MX16(CAST(STRING(10)bit)((INT I=1..10)n[11..I]) CONC ALL SAME(6)B TO S o[10],sel[1..4]),
  MX16(CAST(STRING(11)bit)((INT I=1..11)n[12..I]) CONC ALL SAME(5)B TO S o[11],sel[1..4]),
  MX16(CAST(STRING(12)bit)((INT I=1..12)n[13..I]) CONC ALL SAME(4)B TO S o[12],sel[1..4]),
  MX16(CAST(STRING(13)bit)((INT I=1..13)n[14..I]) CONC ALL SAME(3)B TO S o[13],sel[1..4]),
  MX16(CAST(STRING(14)bit)((INT I=1..14)n[15..I]) CONC ALL SAME(2)B TO S o[14],sel[1..4]),

```

MX16(CAST{STRING[16]bit}((INT i=1..15)n[16-i])CONC o[15]),sel[1..4]),

MX16(CAST{STRING[16]bit}((INT i=1..16)n[17-i]),sel[1..4]),

MX16(CAST{STRING[16]bit}(b'0' CONC ((INT i=1..15)n[17-i]),sel[1..4]),

MX16(ZERO[2]b'0' CONC CAST{STRING[14]bit}((INT i=1..14)n[17-i]),sel[1..4]),

MX16(ZERO[3]b'0' CONC CAST{STRING[13]bit}((INT i=1..13)n[17-i]),sel[1..4]),

MX16(ZERO[4]b'0' CONC CAST{STRING[12]bit}((INT i=1..12)n[17-i]),sel[1..4]),

MX16(ZERO[5]b'0' CONC CAST{STRING[11]bit}((INT i=1..11)n[17-i]),sel[1..4]),

MX16(ZERO[6]b'0' CONC CAST{STRING[10]bit}((INT i=1..10)n[17-i]),sel[1..4]),

MX16(ZERO[7]b'0' CONC CAST{STRING[9]bit}((INT i=1..9)n[17-i]),sel[1..4]),

MX16(ZERO[8]b'0' CONC CAST{STRING[8]bit}((INT i=1..8)n[17-i]),sel[1..4]),

MUX_8(bit)(b'0,n[16],n[15],n[14],n[13],n[12],n[11],n[10],CAST{[3]boolsel_mux8_high),

MUX_8(bit)(b'0,b'0,n[16],n[15],n[14],n[13],n[12],n[11],CAST{[3]boolsel_mux8_high),

MUX_8(bit)(b'0,b'0,b'0,n[16],n[15],n[14],n[13],n[12],CAST{[3]boolsel_mux8_high),

MUX_8(bit)(b'0,b'0,b'0,b'0,n[16],n[15],n[14],n[13],CAST{[3]boolsel_mux8_high),

MX_4(bit)(b'0,n[16],n[15],n[14],CAST{[2]boolsel_mux4_high),

MX_4(bit)(b'0,b'0,n[16],n[15],CAST{[2]boolsel_mux4_high),

MX_4(bit)(b'0,b'0,b'0,n[16],CAST{[2]boolsel_mux4_high),

b'0

)

END.

MAC_REV_4 = (STRING[4]bit:n) ->STRING[4]bit:CAST{STRING[4]bit}((n[4],n[3],n[2],n[1])).

#in is data from bus, fifo empty is input fifo control#

FN_HUFFMAN_DECODE = (mode:mode,STRING[2]bit:token_length_in,STRING[32]bit:buffer,STRING[5]bit:s)

```

->(bit_t_input,STRING[2]bit#token#):

BEGIN
    MAKESHIFT32_16:input_decode.
    COM
    LET mag_out2 = CASE input_decode[9..12]
        OF b"1111":(input_decode[13..16] ADD_U b"10110") #add 22 to give value#
        ELSE input_decode[9..12] ADD_U b"00111" #add 7 to give value#
        ESAC,
    MOC
    LET sel_9_12 = CASE input_decode[9..12]
        OF b"1111":
            ELSE1
            ESAC,
        mag_out2 = CASE sel_9_12
            OF 1:REV_4 input_decode[13..16]
            ELSE REV_4 input_decode[9..12]
            ESAC ADD_U
            CASE sel_9_12
            OF 1: b"10110" #add 22 to give value#
            ELSE b"00111" #add 7 to give value#
            ESAC,
        mag_out_huff=CASE input_decode[1]
            OF b"0":input/0
            ELSE CASE input_decode[3]
                OF b"1":input/1
                ELSE CASE input_decode[4]
                    OF b"1":input/2
                    ELSE CASE input_decode[5]
                        OF b"1":input/3

```

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```

ELSE CASE input_decode[6]
OF b'1:input/4
ELSE CASE input_decode[7]
OF b'1:input/5
ELSE CASE input_decode[8]
OF b'1:input/6
ELSE (S_TO_IN (b'0000' CONC mag_out2))[2]
ESAC
ESAC
ESAC
ESAC
ESAC
ESAC
ESAC,

```

```

#on lpf_still bit 1 is the sign bit#
sign = CASE mode
OF lpf_still:input_decode[1]
ELSE CASE mag_out_huff
OF input/0:b'0
ELSE input_decode[2]
ESAC
ESAC,

```

```

#select huff value, 0(n lpf_send) or real value, rearrange the bits for real data#
#on lpf_still bit 1 is sign bit so discard#
mag_out = CASE mode
OF lpf_still:(S_TO_IN (CAST(STRING(9bit))INT j=1..9)input_decode(1-9))[2]
ELSE mag_out_huff
ESAC,

```

```

token_length = b'000'CONC token_length_in,
#decode token, valid only during a token cycle#
token = CASE token_length[4..5]
  OF b'10':input_decode[1..2],
  b'01':input_decode[1] CONC b'0'
  ESAC.

JOIN (buffer,s) ->input_decode.

OUTPUT (sign,mag_out,token)
END.

#the huffman encoder#
FN HUFFMAN_ENCODE = (t_input: value, bit: sign, STRING[2] bit: token, t_mode: mode, t_cycle: cycle,
  STRING[16] bit: buffer, STRING[5] bit: s)
  -> (STRING[32] bit):
BEGIN
  MAKE SHIFT 16X16_32: shift.
  #encode value#
  LET header = CAST(STRING[2] bit)(b'1,sign).
  value_bit = CAST([(16] bit)(IN TO_S(16) value)[2],
    sub const = CASE value
      OF input/(7..21): b'00111',
      input/(22..37): b'10110'
      ELSE b'00000'
      ESAC,

```

sub_value = ((IN_TO_S(input_exp)value)[2] SUB_U sub_const)[8..11],

enc_value =

CASE cycle

OF token_cycle: token CONC ZERO{14}b"0"; #token is msb, max 2 bits#

data_cycle: CASE mode

#on intra & LPF pass thro value as 16 bit word, and reverse bit order, place sign first next to lsb#

OF lpf_still: CAST{STRING{1}bit} sign CONC CAST{STRING{15}bit} ((INT [-1..15]value_bit[17-i])

#otherwise value is to Huffman encoded, so out 16 bit as this is the max, the shift removes the extra bits#

ELSE CASE value

OF input/0: b"0" CONC ZERO{15}b"0",

input/1: header CONC b"1" CONC ZERO{13}b"0",

input/2: header CONC b"01" CONC ZERO{12}b"0",

input/3: header CONC b"001" CONC ZERO{11}b"0",

input/4: header CONC b"0001" CONC ZERO{10}b"0",

input/5: header CONC b"00001" CONC ZERO{9}b"0",

input/6: header CONC b"000001" CONC ZERO{8}b"0",

input/(7..21): header CONC b"000000" CONC (REV_4 sub_value) CONC ZERO{4}b"0", #sub 7 to give value#

input/(22..37): header CONC b"00000001111" CONC (REV_4 sub_value) #sub 22 to give value#

ELSE header CONC b"0000000111111111"

ESAC

ESAC,

skip_cycle: ZERO{16}b"0" #dummy value#

ESAC.

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```
JOIN (buffer_enc_value,s[2..5]) ->shift.
```

```
#max value is 37 so 8 bits enough#
OUTPUT shift
END.
```

```
# some basic macros for the convolver, assume these will#
#be synthesised into leaf cells#
MAC MX_4(TYPE ty)=(ty:in1 in2 in3 in4, [2]boot:sel) ->ty:
CASE sel
OF (f,f):in1,
   (f,f):in2,
   (f,f):in3,
   (f,f):in4
ESAC.
```

```
MAC ENCODE4_2 = (t_max4:in) ->[2]boot:
CASE in
OF uno:(f,f),
   dos:(f,f),
   tres:(f,f),
   quatro:(f,f)
ESAC.
```

```
MAC ENCODE3_2 = (t_max3:in) ->[2]boot:
CASE in
OF t:(f,f),
   c:(f,f),
```

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r:(t,f)
ESAC.

MAC_MUX_3(TYPE t)=(t:in1 in2 in3, t_mux3:sel) ->t:
MX_4(t)(in1,in2,in3,in1,ENCODE3_2 sel).

MAC_MUX_4(TYPE t)=(t:in1 in2 in3 in4, t_mux4:sel) ->t:
MX_4(t)(in1,in2,in3,in4,ENCODE4_2 sel).

MAC_MUX_2(TYPE t)=(t:in1 in2, t_mux:sel) ->t:
CASE sel
OF left:in1,
right:in2
ESAC.

MAC_MUX_8(TYPE ty)=(ty:in1 in2 in3 in4 in5 in6 in7 in8, [3]bool:sel) ->ty:
CASE sel
OF ((f,f):in1,
(f,f,f):in2,
(f,f,f):in3,
(f,f,f):in4,
(f,f,f):in5,
(f,f,f):in6,
(f,f,f):in7,
(f,f,f):in8
ESAC.

MAC_MUX16=(STRING[16]bit:in, STRING[4]bit:sel) ->bit:
CASE sel
OF b"0000":in[1],
b"0001":in[2],

```

b'0010':in[3],
b'0011':in[4],
b'0100':in[5],
b'0101':in[6],
b'0110':in[7],
b'0111':in[8],
b'1000':in[9],
b'1001':in[10],
b'1010':in[11],
b'1011':in[12],
b'1100':in[13],
b'1101':in[14],
b'1110':in[15],
b'1111':in[16]
ESAC.
COM
MAC MX16={STRING[16]bit:n, STRING[4]bit:sel} ->bit:
MUX_2(bit){
  MUX_8(bit){in[1],in[2],in[3],in[4],in[5],in[6],in[7],in[8],CAST([3]bool)sel[2..4]}.
  MUX_8(bit){in[9],in[10],in[11],in[12],in[13],in[14],in[15],in[16],CAST([3]bool)sel[2..4]}.
  CASE sel[1]
  OF b'0:left
  ELSE right
  ESAC).
MOC

MAC INT_BOOL = (t_quant:c) ->[3]bool:
CASE q
OF quant/0:(f,f,f),
  quant/1:(f,f,f),
  quant/2:(f,f,f),

```

```

quant/3:(1,1,1),
quant/4:(1,1,0),
quant/5:(1,1,1),
quant/6:(1,1,0),
quant/7:(1,1,1)
ESAC.

```

```

COM
MAC_MUX_3(TYPE t)=(t:in1 in2 in3, t_mux3:sel) ->t:
CASE sel
OF:in1,
   c:in2,
   r:in3
ESAC.

```

```

MAC_MUX_4(TYPE t)=(t:in1 in2 in3 in4, t_mux4:sel) ->t:
CASE sel
OFuno:in1,
   dos:in2,
   tres:in3,
   quatro:in4
ESAC.
MOC

```

```

FN NOT = (bool:in) ->bool:CASE in OF t:f,t ESAC.

```

```

FN XOR = (bool: a b) ->bool:
CASE (a,b)
OF (1,0)|(0,1):1
ELSE 1
ESAC.

```

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```

JOIN in->del.
OUTPUT del
END.

```

```

#a resetable OFF, init value is input parameter#
MAC DFF_INIT(TYPE t)=(boot:ck,t,reset:reset,t,load:load,t,in init_value) ->t
BEGIN
  MAKE DEL(t):del.
  LET out=CASE (load,reset)
    OF (write,t,reset):in,
      (read,rst):init_value
    ELSE del
    ESAC.
  JOIN out->del.
  OUTPUT CASE reset
    OF rst:init_value
    ELSE del
    ESAC
  END.

```

```

#a dff resetable non-loadable dff#
MAC DFF(TYPE t)=(boot:ck,t,reset:reset,t,in init_value) ->t:
BEGIN
  MAKE DEL(t):del.
  JOIN in->del.
  OUTPUT CASE reset
    OF rst:init_value
    ELSE del
    ESAC
  END.

```

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```

MAC PDEL(TYPE t,INT n) = (t:in) ->t
IF n=0 THEN DEL(t):in
ELSE PDEL(t,n-1) DEL(t) in
FI.

MAC PDF1(TYPE t,INT n) = (boi:ck,t:in) ->t
IF n=0 THEN DF1(t)(ck,in)
ELSE PDF1(t,n-1)(ck,DF1(t)(ck,in))
FI.

#generates the new_mode from the old, and outputs control signals to the tokeniser#

FN MODE_CONTROL = (boi:ck, t_reset:reset, t_intra:intra_inter,boi:lpf_done,[7]boi:flags,
STRING[2]bit:token_in,t_octave:octave,t_state:state,t_direction:direction,t_load:load_mode_in
,t_cycle:cycle)
->(t_mode,t_mode,STRING[2]bit,t_diff,STRING[2]bit,t_mode):
#new_mode,proposed mode,current token,difference,token_length,#
BEGIN

MAKE [4]DFF_INIT(t_mode):mode,
DFF_INIT(t_diff):diff_out,
DFF_INIT(t_mode):next_mode.
LET nzflag=flags[1],
origIn=flags[2],
noflag=flags[3],
ozflag=flags[4],
motion=flags[5],
pro_new_z = flags[6],
pro_no_z = flags[7].

```

lpf_done_del = DFF(bool){ck, reset, lpf_done, 0}. #synchronise mode change at end of LPF#

LET next = (SEQ

#the proposed value for the mode at that octave, flags etc will change this value as necessary#
#proposed, or inherited mode from previous tree#

VAR pro_mode := CASE reset
OF rst:CASE intra_inter #reset on frame start, so do lpf#

OF intra:lpf_still
ELSE lpf_send
ESAC

ELSE CASE lpf_done_del

OF:CASE intra_inter #store default mode in mode[4]#
OF intra:still
ELSE send
ESAC

ELSE CASE state

OF down1:mode[3], #jump sideways in ocd/1#
, up0:mode[4]

ELSE CASE octave

OF ocd/0:mode[1],
ocd/1:mode[2],
ocd/2:mode[3]
ESAC

ESAC

ESAC

ESAC,

new_mode:=pro_mode, #inherit the previous mode#
token_out:=b"00".

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```

difference:=nodiff,
token_length:=b"00",
flag:=f,
CASE direction
OF forward:
CASE pro_mode
OF void:CASE ozflag
OF tnew_mode:=stop
ELSE
ESAC, #stay in these modes until end of tree#
void_still: , #intra so must zero out all of tree#
still_send:(token_length:=b"01";
CASE (nzflag OR pro_new_z)
OF t(token_out:=b"00";
CASE ozflag
OF tnew_mode:=stop
ELSE new_mode:=void
ESAC)
ELSE (token_out:=b"10";
new_mode:=still_send)
ESAC
),
send: CASE ozflag
OF t(token_length:=b"01";
CASE (nzflag OR pro_new_z)

```



```

OF t:(token_out:=b"00";
  new_mode:=stop)
ELSE (token_out:=b"10";
  new_mode:=still_send)
ESAC
)
ELSE (token_length:=b"10";

CASE ( NOT(nzflag OR motion) AND NOT(nzflag)
OFT:(CASE origin
  OF tflag:=pro_new_z
  ELSE (flag:=pro_no_z;
    difference:=diff)
  ESAC;
CASE flag
OFT:(token_out:=b"10";
  new_mode:=void)
ELSE CASE origin
  OF t:(token_out:=b"01";
    new_mode:=still_send)
  ELSE (token_out:=b"11";
    new_mode:=send)
  ESAC
ESAC)
ELSE

CASE (motion OR origin)AND nzflag
OFT:(token_out:=b"10";
  new_mode:=void)
ELSE (token_out:=b"00";
  new_mode:=stop)

```

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```

    ESAC
    ESAC
    )
    ESAC,

```

```

still: (token_length:=b'01";
CASE (nzflag OR pro_new_z)
OF: (token_out:=b'00";
    new_mode:=vold_still) #zero out tree#
ELSE (token_out:=b'10";
    new_mode:=still)
ESAC
),

```

```

(lpf_still): (token_out:=b'00";
    token_length:=b'00");

```

#for ELLA only DUMB!!#

```

(lpf_send): (difference:=diff;
    token_length:=b'01";

```

```

CASE (noflag OR pro_no_z)
OF t(token_out:=b'00";
    new_mode:=lpf_stop)
ELSE (token_out:=b'10";
    new_mode:=lpf_send) #as mode stop but for this block only#

```

ESAC)

ESAC,

inverse:

CASE pro_mode

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```

OF void: CASE ozflag
  OF t:new_mode:=stop
  ELSE
  ESAC,

void_still: ,

send: CASE ozflag
  OF!(token_length:=b'01"; #repeat of still-send code#
    CASE token_in[1]
    OF b'1:new_mode:=still_send,
       b'0:new_mode:=stop
    ESAC
    )
  ELSE (token_length:=b'10";
    CASE token_in
    OF b'11": (difference:=diff;
               new_mode:=send),
       b'01":new_mode:=still_send,
       b'10":new_mode:=void,
       b'00":new_mode:=stop
    ESAC
    )
  ESAC,

still_send: (token_length:=b'01";
  CASE token_in[1]
  OF b'1:new_mode:=still_send,
     b'0: CASE ozflag
           OF!new_mode:=stop

```

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```

ELSE new_mode:=void
ESAC
ESAC
),
still: (token_length=b'01";
CASE token_in[1]
OF b'1:new_mode:=still,
b'0:new_mode:=void_still
ESAC
),
(lpf_send):(difference:=diff;
token_length:=b'01";
CASE token_in[1]
OF b'0:new_mode:=lpf_stop,
b'1:new_mode:=lpf_send
ESAC),
lpf_still:
ESAC
ESAC;

OUTPUT (new_mode,pro_mode,token_out,difference,token_length)
).

LET load_mode = CASE (reset,lpf_done_def) #store base mode in mode[3]& mode[4], base changes after lpf#
OF (rst,boof)(t_reset,t):(read,read,write,write)
ELSE CASE (octave,load_mode_in)

```

```

OF  (oct/1,write):(write,write,read,read),
    (oct/2,write):(read,write,write,read)
ELSE (read,read,read,read)
ESAC
ESAC.
#save the new mode& difference during a token cycle, when the flags and tokens are valid#
JOIN  (ck,reset,CASE cycle
      OF token_cycle:write
      ELSE read
      ESAC, next[1],still)    ->next_mode,

      (ck,reset,CASE cycle
      OF token_cycle:write
      ELSE read
      ESAC, next[4],nodiff)    ->diff_out.

#now write the new mode value into the mode stack at end of cycle, for later use #
FOR INT i=1..4 JOIN  (ck,no_rst,load_mode[i],CASE (reset,lpf_done_del)
                    OF (no_rst,1)((rst,bool):next[2]
                     ELSE next_mode
                     ESAC,still) ->mode[i].
#dont update modes at tree base from lpf data, on reset next[1] is undefined#

OUTPUT (next_mode,next[2],next[3],diff_out,next[5],next[1])
END.

#the tree coder chip#
#threshold = 2*quant_norm#

```

```

FN PALMAS= (bool:ck,reset:reset,t_direction:direction,t_intra:intra_inter,t_channel_factor:channel_factor,

```

```
[4]t_quant:quant_norm, STRING[16]bit:buffer_in,
t_input:new old,[4]t_result:threshold,t_fifo:ffo_full_fifo_empty, STRING[xsize]bit:col_length,
STRING[ysize]bit:row_length, STRING[xsize]bit:ximage_string, #ximage#
STRING[ysize]bit:yimage_string, STRING[11]bit:yimage_string_3#yimage&yimage*2.5#)
```

```
->(t_input,t_sparc_addr,(t_load,t_cs),(t_load,t_cs),STRING[16]bit,[2]t_load,bool,t_cycle):
```

```
#old,address,(rw_new,cs_new),(rw_old,cs_old),buffer_out,fifo_read_fifo_write,cycle#
```

```
BEGIN
```

```
MAKEDECIDE:decide.
```

```
ADDR_GEN:addr_gen,
```

```
HUFFMAN_ENCODE:huffman_encode,
```

```
FIFO_BUFFER:ffo_buffer,
```

```
HUFFMAN_DECODE:huffman_decode,
```

```
MODE_CONTROL:mode,
```

```
CONTROL_COUNTER:control_counter,
```

```
BLK_SUB_COUNT:sub_count,
```

```
OFF_INIT(t_channel):channel,
```

```
QUANT:quant.
```

```
LET
```

```
nzflag=decide[1],
```

```
origin=decide[2],
```

```
noflag=decide[3],
```

```
ozflag=decide[4],
```

```
motion=decide[5],
```

```
pro_no_z = decide[7], #pro_no_z or pro_new_z#
```

```
pro_new_z = decide[6],
```

```

new_mode = mode[1],
pro_mode = mode[2],
token_out = mode[3],
difference = mode[4],
token_length = mode[5],

```

```

pro = quant[1], #pro_no, or pro_new#
lev_out = (S_TO_IN quant[2])[2], #corresponding level#
sign = quant[3], #and sign #

```

```

octs = addr_gen[2],
sub_en = addr_gen[3],
tree_done = addr_gen[4],
lpf_done = addr_gen[5],
state = addr_gen[6],

```

```

cycle = control_counter[2],
cs_new = control_counter[7],
rw_new = read,
rw_old = control_counter[8],
cs_old = control_counter[9],

```

```

load_channel = CASE (sub_en, sub_count[2]) #change channel#
  OF (1): write
  ELSE read
  ESAC,

```

```

new_channel = CASE channel_factor
  OF luminance: y
  ELSE CASE channel
    OF y-u,

```

```

    uv,
    vy
    ESAC
    ESAC,
    #flush the buffer in the huffman encoder#
    flush_buffer = DFF(bool){ck,reset,CASE channel_factor
    OF luminance:CASE load_channel
    OF write:t
    ELSE f
    ESAC,
    color: CASE (channel,load_channel)
    OF (v,write):t
    ELSE f
    ESAC
    ESAC,f),
    ESAC,f),

    frame_done = PDF1{bool,1}{ck,flush_buffer},

    fifo_write=fifo_buffer[6],
    fifo_read=fifo_buffer[5],
    s=fifo_buffer[4],

    buffer_out = fifo_buffer[1],

    lev_in = huffman_decode[2],
    sign_in = huffman_decode[1],
    token_in = huffman_decode[3],

    del_new = PDF1{t_input,4}{ck,new),

```



```

#old has variable delays for inverse#
del_old = CASE (direction,pro_mode)
  OF (forward,t_mode))(inverse,send|still_send|lpf_send|void): PDF1(t_input,4)(ck,old)
  ELSE PDF1(t_input,1)(ck,old)
  ESAC,
decide_reset=CASE reset
  OF rstst
  ELSE control_counter[3]
  ESAC,

oct_sel = CASE pro_mode
  OF lpf_still|lpf_send|lpf_stop:quatro
  ELSE CASE (octs,channel)
    OF (oct/0,y):uno,
      (oct/1,y)(oct/0,u,v):dos,
      (oct/2,y)(oct/1,u,v):tres
    ESAC
  ESAC,

threshold_oct = MUX_4(t_result)(threshold[1],threshold[2],threshold[3],threshold[4],oct_sel),

quant_oct = MUX_4(t_quant)(quant_norm[1],quant_norm[2],quant_norm[3],quant_norm[4],oct_sel).

JOIN (ck,decide_reset,threshold_oct,new,old,threshold_oct,threshold_oct,octs,control_counter[6]) ->decide,

(ck,reset,intra_inter,lpf_done,decide,token_in,octs,state,direction,control_counter[1],cycle)->mode,

#delay the new&old values by 5 or 1 depending on mode & direction#
((IN TO S(input_exp|del_new)[2], (IN TO S(input_exp|del_old)[2],
  (IN TO S(input_exp|lev_in)[2], sign_in,direction,quant_oct,difference,pro_mode) ->quant,

```

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```

(ck,reset,new_channel,channel,load_channel_sub_count[1],col_length,row_length,
ximage_string,yimage_string,yimage_string_3,control_counter[4],control_counter[5],new_mode)->addr_gen,

(ck,reset,direction,cycle,pro_mode,lev_out,huffman_decode[2],buffer_in,fifo_full,
fifo_empty,huffman_encode,token_length,flush_buffer,quant_norm[4])    ->fifo_buffer,

(lev_out,sign,token_out,pro_mode,cycle,fifo_buffer[2],s)    ->huffman_encode,

(pro_mode,token_length,fifo_buffer[2] CONC fifo_buffer[3],fifo_buffer[4])    ->huffman_decode,

(ck,reset,sub_en,1,t)    ->sub_count,

(ck,reset,pro_mode,new_mode,direction)    ->control_counter,

(ck,reset,load_channel,new_channel,y)    ->channel.

OUTPUT

(CASE new_mode
OF void|void_still:input/0
ELSE (S TO INpro)[2]
ESAC ,addr_gen[1],(rw_new,cs_new),(rw_old,cs_old),buffer_out,(fifo_read,fifo_write),frame_done,cycle)
END.
COM
#the decoder for the barrel shifter-- decides if the bit value and q value are #
#in the upper-triangle, or diagonal and set the control bits #
MAC DECODE(INT n) = (t_quant:q) ->[qmax](bool#upper diag#,bool#diagonal#):
BEGIN
#one bit of the decoder#
MAC DECODE_BIT(INT j) = (t_quant:q) -> (bool,bool):
CASE q

```

```

MAC BARREL_SHIFT_RIGHT = (t_quant:q.STRING(INT n)bit:data) ->(STRING(n)bit#level#):
MUX_8(STRING(n)bit){
  data,
  b"0"CONC data[1..n-1],
  b"00"CONC data[1..n-2],
  b"000"CONC data[1..n-3],
  b"0000"CONC data[1..n-4],
  b"00000"CONC data[1..n-5],
  b"000000"CONC data[1..n-6],
  b"0000000"CONC data[1..n-7],
  INT_BOOL q.
}

```

#the bshift for the inverse, to generate the rounded level #

```

MAC BARREL_SHIFT_LEFT = (t_quant:q.STRING(INT n)bit:data#lev#) ->(STRING(n)bit#round_level#):
MUX_8(STRING(n)bit){
  data,
  data[2..n]CONCb"0",
  data[3..n]CONCb"01",
  data[4..n]CONCb"011",
  data[5..n]CONCb"0111",
  data[6..n]CONCb"01111",
  data[7..n]CONCb"011111",
  data[8..n]CONCb"0111111",
  INT_BOOL q.
}

```

#the function to return the quantised level(UNSIGNED), and proposed value given, #

the new&old values, forw/inverse direction

```

FN QUANT = (STRING(input_exp)bit: new old lev_inv.bit:sign_lev_inv, t_dir:clor:direction, t_quant:q, t_diff: difference,
  t_mode: mode)

```

-> (STRING[input_exp]bit,STRING[input_exp]bit,bit) #pro,lev& sign# :

BEGIN

LET

#decide which of new-old or new will be quantised, and the sign of the level#
#level is stored in sign & magnitude form#

dir_sel = CASE direction
OF forward:left,
inverse:right
ESAC,

sub_sel = CASE difference
OF diff:left
ELSE right #put old=0#
ESAC,

sub_in= MUX_2(STRING[input_exp]bit)(old,ZERO(input_exp)b'0',sub_sel),

no =ADD_SUB_ST(new,sub_in,subt),

lev_final= ABS_S no, #now input_exp+1 bits#

sgn_level = MUX_2(bit) #sign of value to be quantised#
no[1],
sign_lev_inv,
dir_sel).

#find the quant. level by shifting by q, for the inverse it comes from the Huffman decoder#

```
LET
  lev_data = BARREL_SHIFT_RIGHT(q,lev_final).
```

#saturate the lev at 37, for the Huffman table, except in lpf_still mode, send all the bits#

```
lev_forw = CASE mode
  OF lpf_still:lev_data
  ELSE CASE lev_data GT_U b'00000100101"
    OF: b'00000100101"
    ELSE lev_data
    ESAC
  ESAC,
```

```
lev = MUX_2(STRING(input_exp+1)bit){
  lev_forw,
  b'0" CONC lev_inv,
  dir_sel,
```

#the level = 0 flag#

```
lev_z = lev EQ_U ZERO(input_exp+1)b'0",
```

```
inv_lev_z = CASE lev_z
  OF tb'0
    ELSE b'1
  ESAC,
```

#the level value shifted up, and rounded#

```
round_lev = BARREL_SHIFT_LEFT(q,lev) AND_B
```

CASE mode

```
OF lpf_still: b'00" CONC ALL_SAME(input_exp-1)b'1"
```

```
ELSE BIT_STRING(input_exp+1)(input_exp+1)inv_lev_z) #if lev==0 out all 0's#
```

```

        ESAC,
        #clear out extra bit for lpf still case#

        #calculate the proposed value: in the case n-o, round_lev is unsigned 10 bit, so result needs 11 bits#
        #pro_no will always be in range as round_lev < (n-o) #

        pro_no = ADD SUB ST( old_round_lev, CASE sgn_level
            OF b'0': add,
               b'1': subtr
            ESAC),

        #now pro_new = +/- round_lev#

        round_sel = CASE sgn_level
            OF b'0': left,
               b'1': right
            ESAC,

        pro_new = MUX_2( STRING[input_exp+1]bit(
            round_lev,
            (NEG_U round_lev)[2..input_exp+2], #NEG sign extends#
            round_sel),

        out_sel = CASE difference
            OF diff: left
            ELSE right
            ESAC.

        OUTPUT (MUX_2(STRING[input_exp]bit(

```

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```

    pro_no[3..input_exp+2],
    pro_new[2..input_exp+1],
    out_sel),
    lev[2..input_exp+1],
    sgn_level)

```

```

END.
#actel 1 bit full adder with active low cin and cout#
FN FA1B = (bit: ain bin c1nb) -> (bit: bit1: #c1nb, s#)
BEGIN
    LET a_c = B_TO_S ain CONC NOT_B(B_TO_S c1nb),
        b_c = B_TO_S bin CONC NOT_B(B_TO_S c1nb),
        out = ADD_U(a_c, b_c),
        OUTPUT(CAST(bit) NOT_B(B_TO_S out[1]), out[2])
END.

```

#a Ripple carry adder using 1 bit full adder blocks#

#the actel version of the ADD BIOP's#

```

MAC ADD_S_ACTEL = (STRING(INT m) bit: ain, STRING(INT n) bit: bin, bit: c1nb) -> STRING(IF m>=n THEN m+1 ELSE n+1) FI bit:
BEGIN
    MAKE (IF m>=n THEN m ELSE n) FI FA1B sum.

```

#signed nos so sign extend #

```

LET a_c = IF m>=n THEN ain ELSE ALL_SAME(n-m) B_TO_S ain[1] CONC ain FI,
    b_c = IF n>=m THEN bin ELSE ALL_SAME(m-n) B_TO_S bin[1] CONC bin FI,
    LET subsignal = sum,
    #isb#

```

```

JOIN  (a_c|IF m>=n THEN m ELSE n FI),b_c|IF m>=n THEN m ELSE n FI),c|nb) ->sum|IF m>=n THEN m ELSE n FI).

FOR INT j=1..(IF m>=n THEN m ELSE n FI) -1
JOIN (a_c|IF m>=n THEN m ELSE n FI)-j),b_c|IF m>=n THEN m ELSE n FI)-j).
sum|(IF m>=n THEN m ELSE n FI) -j+1|1)) ->sum|(IF m>=n THEN m ELSE n FI) -j).

OUTPUT CAST{STRING|IF m>=n THEN m+1 ELSE n+1 FI|bit}
(NOT B|B TO S sum{1|1}) CONC
CAST{STRING|IF m>=n THEN m ELSE n FI|bit} (INT j=1..IF m>=n THEN m ELSE n FI) sum{j|2))
END.

MAC ADD_US_ACTEL = (STRING(INT m)|bit:aln,STRING(INT n)|bit:bin,bit:c|nb) ->STRING|IF m>=n THEN m+1 ELSE n+1 FI|bit:
BEGIN
MAKE |IF m>=n THEN m ELSE n FI|FA1B:sum.

#unsigned nos so extend by 0#
LET a_c = IF m>=n THEN aln ELSE ZERO(n-m)b'0' CONC aln FI,
b_c = IF n>=m THEN bin ELSE ZERO(m-n)b'0' CONC bin FI.
LET subsignal = sum.

#|sb#
JOIN (a_c|IF m>=n THEN m ELSE n FI),b_c|IF m>=n THEN m ELSE n FI),c|nb) ->sum|IF m>=n THEN m ELSE n FI).

FOR INT j=1..(IF m>=n THEN m ELSE n FI) -1
JOIN (a_c|IF m>=n THEN m ELSE n FI)-j),b_c|IF m>=n THEN m ELSE n FI)-j).
sum|(IF m>=n THEN m ELSE n FI) -j+1|1)) ->sum|(IF m>=n THEN m ELSE n FI) -j).

OUTPUT CAST{STRING|IF m>=n THEN m+1 ELSE n+1 FI|bit}
(NOT B|B TO S sum{1|1}) CONC
CAST{STRING|IF m>=n THEN m ELSE n FI|bit} (INT j=1..IF m>=n THEN m ELSE n FI) sum{j|2))

```


END.

MAC_ADD_SUB_ST = (STRING(INT m)bit:ain, STRING(INT n)bit:bin, t_add:sel) -> STRING(IF m>=n THEN m+1 ELSE n+1 F)bit;

BEGIN

#sign extend inputs#

LET a_s = CAST(STRING(1)bit:ain(1)) CONC ain,

b_s = CAST(STRING(1)bit:bin(1)) CONC bin,

sel_bit = CAST(STRING(1)bit:sel,

#ACTEL#

bin_inv = XOR_B(n+1)(b_s, ALL_SAME(n+1)sel_bit),

#c1nb is active low so cast sel(add->0,sub->1) & invert it#

out = ADD_S_ACTEL(a_s, bin_inv, CAST(bin)NOT_B sel_bit),

binout = out[2..IF m>=n THEN m+2 ELSE n+2 F]

OUTPUT binout

END.

#transformation ops#

MAC_B_TO_S = (bit:in) -> STRING(1)bit: CASE in

OF b'0:b'0',

b'1:b'1'

ESAC.

MAC_I_TO_SC(INT n) = (t_result:in) -> (flag,t_input): BIOP_TRANSFORM_S.

MAC_SC_TO_I(INT n) = (STRING(n)bit:in) -> (flag,t_result): BIOP_TRANSFORM_S.

MAC_S_TO_IN = (STRING(INT n)bit:in) -> (flag,t_input): BIOP_TRANSFORM_S.

MAC_IN_TO_S(INT n) = (t_input:in) -> (flag,STRING(n)bit): BIOP_TRANSFORM_S.

```

MAC U_TO_IN = (STRING(INT n)bit:in) -> (flag,!_input): BIOP TRANSFORM_US.

MAC U_TO_LEN = (STRING(INT n)bit:in) -> (flag,!_length): BIOP TRANSFORM_US.
MAC_LEN_TO_U(INT n) = (!_length:in) -> (flag,STRING(n)bit): BIOP TRANSFORM_US.

MAC Q_TO_U(INT n) = (!_quant:in) -> (flag,STRING(n)bit): BIOP TRANSFORM_US.
MAC S_TO_C = (STRING(INT n)bit:in) -> (flag,!_col): BIOP TRANSFORM_US.
MAC S_TO_R = (STRING(INT n)bit:in) -> (flag,!_row): BIOP TRANSFORM_US.
MAC S_TO_B = (STRING(INT n)bit:in) -> (flag,!_blk): BIOP TRANSFORM_US.
MAC S_TO_SUB = (STRING(INT n)bit:in) -> (flag,!_sub): BIOP TRANSFORM_US.
MAC S_TO_SPARC = (STRING(INT n)bit:in) -> (flag,!_sparc_addr): BIOP TRANSFORM_US.

MAC C_TO_S(INT n) = (!_col:in) -> (flag,STRING(n)bit): BIOP TRANSFORM_US.
MAC R_TO_S(INT n) = (!_row:in) -> (flag,STRING(n)bit): BIOP TRANSFORM_US.

MAC I_TO_Q = (!_input:in) -> !_quant: ARITH in.

MAC B_TO_I = (bit:in) -> !_result: CASE in
    OF b'0: result/0,
       b'1: result/1
    ESAC.

MAC CARRY = (!_addr:in) -> STRING(1)bit: CASE in
    OF addr'b'0",
       sub'b'1"
    ESAC.

MAC BOOL_BIT = (bool:in) -> STRING(1)bit:
CASE in
    OF t'b'1"

```

ELSE b'0'
ESAC.

MAC BOOL_STRING(INT n) = ((n)bit:in) ->STRING[n] bit:
(LET out = BOOL_BIT ln[1].
OUTPUT IF n=1

THEN out

ELSE out[1] CONC BOOL_STRING(n-1){(n[2..n]}

FI

).

MAC BIT_STRING(INT n) = ((n)bit:in) ->STRING[n] bit:
(LET out = B_TO_S ln[1].

OUTPUT IF n=1

THEN out

ELSE out[1] CONC BIT_STRING(n-1){(n[2..n]}

FI

).

MAC ZERO(INT n) = (STRING[1]bit:dummy) ->STRING[n]bit:

IF n=1 THEN b'0'

ELSE b'0' CONC ZERO(n-1) b'0'

FI.

MAC ALL_SAME(INT n) = (STRING[1]bit:dummy) ->STRING[n]bit:

IF n=1 THEN dummy

ELSE dummy CONC ALL_SAME(n-1) dummy

FI.

COM

The operators described in this section are optimal and take two-valued operands and produce a two-valued result. They may not be used with ELLA-integers or associated types.

The first basic value of any two-valued type declaration of the operand(s) and the result are interpreted by the operations as false, and the second basic value is interpreted as true. Thus, given the following type declarations:

MOC

$$\text{MAC AND_T} = (\text{TYPE t a b}) \rightarrow \text{t: BIOP AND.}$$

$$\text{MAC OR_T} = (\text{TYPE t a b}) \rightarrow \text{t: BIOP OR.}$$

$$\text{MAC XOR_T} = (\text{TYPE t a b}) \rightarrow \text{t: BIOP XOR.}$$

$$\text{MAC NOT_T} = (\text{TYPE t a}) \rightarrow \text{t: BIOP NOT.}$$

COM

The following operations take bit-string operand(s) and are bitwise, i.e. the operation is performed on the operand(s) one bit at a time. The operand(s) and result must all be ELLA-strings of the same length.

MOC

$$\text{MAC AND_B} = (\text{STRINGINT n bit, STRING(n bit)}) \rightarrow \text{STRING(n bit): BIOP AND.}$$

$$\text{MAC OR_B} = (\text{STRINGINT n bit, STRING(n bit)}) \rightarrow \text{STRING(n bit): BIOP OR.}$$

MAC XOR_B = (STRING(INT n)bit, STRING(n)bit) -> STRING(n)bit:
BIOP XOR.

MAC NOT_B = (STRING(INT n)bit) -> STRING(n)bit:
BIOP NOT.

COM

The operators described in this section may be used with primitive types ie all enumerated types, except associated types, rows, strings and structures. These operations take two operands which must be of the same type and the result can be any two-valued type; we have packaged these BIOPs so they output a value of type 'bool' - you may change this if you wish.

MOC

MAC EQ = (TYPE t: a b) -> bool: BIOP EQ.

MAC GT = (TYPE t: a b) -> bool: BIOP GT.

MAC GE = (TYPE t: a b) -> bool: BIOP GE.

MAC LT = (TYPE t: a b) -> bool: BIOP LT.

MAC LE = (TYPE t: a b) -> bool: BIOP LE.

COM

NOTE: these BIOPs are designed to take any primitive ELLA type. Since it is not possible to distinguish between primitive and other types, whilst leaving the macro declaration general enough to allow the use of all two-valued types that might be declared, there are type-checking limitations. This is done at network assembly, so use of illegal types will not generate an error

message until then.

NB: ARITH provides for relational operations on ELLA-integer types.

MOC

COM

These operations are optimal in their handling of '?' and operate on bit-string representations of unsigned integers. The result may be any two-valued type; we have used type 'bool'. The inputs can be of different lengths and different types.

MOC

MAC EQ_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP EQ_US.

MAC GT_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP GT_US.

MAC GE_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP GE_US.

MAC LT_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP LT_US.

MAC LE_U = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP LE_US.

Bit-strings representing signed numbers

COM

These operations are optimal and operate on bit-string representations of signed integers. The result may be any two-valued type; we have used type

'bool'. The inputs can be of different lengths and different types.

MOC

MAC EQ_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP EQ_S.

MAC GT_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP GT_S.

MAC GE_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP GE_S.

MAC LT_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP LT_S.

MAC LE_S = (STRING[INT n]bit, STRING[INT m]bit) -> bool:
BIOP LE_S.

Shift operations

COM

These operate on bit-strings. Both the enclosing macro and the BIOP are parameterised by the number of bits to be shifted (INT p). The macro and BIOP parameters must match. Note that no bits are lost in these shift operations, so you may need to trim the result to achieve the desired effect.

SR means shift right; SL means shift left.

The macros with the suffix '_S' perform arithmetic shifts; those with the

suffix 'U' perform bool shifts.
MOC

MAC SL_S(INT p) = (STRING(INT n)bit) -> STRING(n + p)bit:
BIOP SL(p).

MAC SL_U(INT p) = (STRING(INT n)bit) -> STRING(n + p)bit:
BIOP SL(p).

MAC SR_S(INT p) = (STRING(INT n)bit) -> STRING(n + p)bit:
BIOP SR_S(p).

MAC SR_U(INT p) = (STRING(INT n)bit) -> STRING(n + p)bit:
BIOP SR_US(p).

Arithmetic operations

Bit-strings representing unsigned numbers

addition.

MAC ADD_U = (STRING(INT m)bit, STRING(INT n)bit)
-> STRING(IF m >= n THEN m+1 ELSE n+1 F)bit:
BIOP PLUS_US.

subtraction on bit-string representations of unsigned integers. Output is #
signed.

MAC SUB_U = (STRING(INT m)bit, STRING(INT n)bit)
-> STRING(IF m >= n THEN m+1 ELSE n+1 F)bit:

BIOP MINUS_US.

negation. Output is signed.

MAC NEG_U = (STRING(INT n)bit) -> STRING(n+1)bit;
BIOP NEGATE_US.

multiplication.

MAC MULT_U = (STRING(INT m)bit, STRING(INT n)bit) -> STRING(m+n)bit;
BIOP TIMES_US.

COM

- divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder, otherwise, the first element is 'error' and the rest is set to '7'.

MOC

MAC DIV_U = (STRING(INT m)bit, STRING(INT n)bit)
-> (flag, STRING(m)bit, STRING(n)bit):

BIOP DIVIDE_US.

square root.

MAC SQRT_U = (STRING(INT n)bit) -> STRING((n+1) % 2)bit;
BIOP SQRT_US.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the modulus; otherwise, the first element is 'error' and the second is '7'.

MOC

MAC MOD_U = (STRING(INT m)bit, STRING(INT n)bit)

-> (flag, STRING(n)bit):

BIOP MOD_US.

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.
MOC

MAC RANGE_U (INT m) = (STRING(INT n)bit)

-> (flag, STRING(m)bit):

BIOP RANGE_US.

Bit-strings representing signed numbers

addition.

MAC ADD_S = (STRING(INT m)bit, STRING(INT n)bit)

-> STRING(IF m >= n THEN m+1 ELSE n+1) F1bit:

BIOP PLUS_S.

subtraction.

MAC SUB_S = (STRING(INT m)bit, STRING(INT n)bit)

-> STRING(IF m >= n THEN m+1 ELSE n+1) F1bit:

BIOP MINUS_S.

negation.

MAC NEG_S = (STRING(INT n)bit) -> STRING(n+1)bit;
 BIOP NEGATE_S.

multiplication.

MAC MULT_S = (STRING(INT m)bit, STRING(INT n)bit) -> STRING(m+n)bit;
 BIOP TIMES_S.

COM

divide. If the divisor is non-zero then the first element of the output is 'ok' and the second and third elements are the quotient and remainder; otherwise, the first element is 'error' and the rest is set to '?'. The remainder has the same sign as the divisor.

MOC

MAC DIV_S = (STRING(INT m)bit, STRING(INT n)bit)
 -> (flag, STRING(m)bit, STRING(n)bit);
 BIOP DIVIDE_S.

COM

modulus (result always positive). If the divisor is non-zero, then the first element of the output is 'ok' and the second element is the unsigned modulus; otherwise, the first element is 'error' and the second is '?'.
 MOC

MAC MOD_S = (STRING(INT m)bit, STRING(INT n)bit)
 -> (flag, STRING(n)bit);
 BIOP MOD_S.

COM

- convert between one range of bit-string and another. If the input value cannot be represented as a legal value for the output string, the result is 'error' and '?'.
MOC

MAC RANGE_S (INT m) = (STRING(INT n)bit)
-> (flag, STRING(m)bit):
BIOP RANGE_S.

absolute value. The output represents an unsigned integer.

MAC ABS_S = (STRING(INT n)bit) -> STRING(m)bit:
BIOP ABS_S.

Built in Register

MAC DREG(INT interval delay) = (TYPE t) -> t:
ALIEN REGISTER {interval, ?t, 0, delay}.

MAC GEN_DREG(INT interval, CONST (TYPE t): init, INT skew delay) = (t) -> t:
ALIEN REGISTER {interval, init, skew, delay}.

Built in type conversion

MAC CAST(TYPE t) = (TYPE s) -> t:
ALIEN CAST.

```

MAC ALL_SAME(INT n) = (STRING(1)bit:dummy) ->STRING(n)bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ALL_SAME" FI.
  OUTPUT IF n=1 THEN dummy
  ELSE dummy CONC ALL_SAME(n-1) dummy
  FI
END.

```

```

MAC CAST {TYPE to} = (TYPE from:in) ->to:ALIEN CAST.

```

```

MAC ZERO(INT n) = (STRING(1)bit:dummy) ->STRING(n)bit:
BEGIN
  FAULT IF n < 1 THEN "N<1 in ZERO" FI.
  OUTPUT IF n=1 THEN b'0'
  ELSE b'0' CONC ZERO(n-1) b'0'
  FI
END.

```

```

MAC B_TO_S = (bit:in) ->STRING(1)bit: CASE in
  OF b'0:b'0',
     b'1:b'1'
  ESAC.

```

```

MAC S_TO_IN = (STRING(input_exp)bit:in) -> (flag,t,input): BIOP TRANSFORM S.
MAC IN_TO_S(INT n) = (t,input:in) -> (flag,STRING(n)bit): BIOP TRANSFORM S.

```

```

MAC S_HUFF = (STRING(6)bit) -> (flag,t,huffman): BIOP TRANSFORM US.
MAC HUFF_S = (t,huffman) -> (flag,STRING(6)bit): BIOP TRANSFORM US.

```

```

MAC BOOL_BIT = (bool:in) ->STRING(1) bit:

```

```

CASE in
OF !b'1"
ELSE b'0"
ESAC.
MAC BIT_BOOL = (bit:in)    ->boot
CASE in
OF b'1:1
ELSE f
ESAC.

```

```

MAC BOOL_STRING(INT n) = ([n]boot:in) ->STRING[n] bit:
(LET out = BOOL_BIT in [1].
OUTPUT IF n=1
THEN out
ELSE out[1] CONC BOOL_STRING(n-1)([n][2..n])
FI

```

);
defines the types used for the 2D wavelet chip#

```

#constant values#
INT result_exp=14,    #length of result arith#
input_exp=10,        #length of 1D convolver input/output#
qmax = 7,            #maximum shift value for quantisation constant#
result_range = 1 SL (result_exp-1),
input_range = 1 SL (input_exp-1),
max_octave=3, #no of octaves=max_octave+1, can not be less in this example#
no_octave=max_octave+1, #"#
ysize = 10, #no of bits for ximage#
ysize = 9, #no of bits for yimage#
ximage=319, #the xdimension - 1 of the image, ie no of cols#

```

yimage=239 #the ydimension -1 of the image, ie no of rows#

```
#int types#
TYPE t_result= NEW result/( -(result_range)..(result_range-1)).
t_input= NEW input/( -(input_range)..(input_range-1)).
t_length= NEW len/(0..15).
t_inp = NEW inp/(0..1023).
t_blk =NEW blk/(0..3).
t_sub =NEW sub/(0..3).
t_col =NEW col/(0..ximage).
t_row =NEW row/(0..yimage).
t_carry =NEW carry/(0..1).
t_quant =NEW quant/(0..qmax).
#address for result&dwt memory, ie 1 frame#
t_sparc_addr =NEW addr/(0..(1 SL_max_octave)*( ximage+1)*(yimage+1)+(ximage+1))-1).
t_octave=NEW oct/(0..(max_octave+1)).
```

#bit string and boolean types types#

```
bit = NEW b(0 | '1).
bool = NEW (ff).
flag = NEW(error | ok).
```

#control signals#

```
t_reset = NEW(res|no_rst).
t_load = NEW(write|read). #r/wbar control#
t_cs = NEW(no_select|select). #chip select control#
t_updown= NEW(down|up). #up/down counter control#
t_diff= NEW(diff|nodiff). #diff or not in quantiser#
t_intra = NEW(intra|inter).
```

```

#convolver mux & and types#
  t_mux = NEW(left|right),
  t_mux3 = NEW(l|c|r),
  t_mux4 = NEW(un|dos|tres|quatro),
  t_add = NEW(add|subt),
  t_direction = NEW(forward|inverse),

#counter types#
  t_count_control = NEW(count_rsl|count_carry),
  t_count_2 = NEW(one|two),

#state types#
  t_token = NEW (t_0|t_1|t_11|t_100|t_101),
  t_mode = NEW(void|void_still|stop|send|still|still_send|pf_send|pf_still|pf_stop),
  t_cycle = NEW(token_cycle|data_cycle|skip_cycle),
  t_state = NEW(start|up0|up1|zz0|zz1|zz2|zz3|down1),
  t_decode = NEW(load_low|load_high),
  t_high_low = NEW(low|high),
  t_huffman = NEW(pass|huffman),
  t_fifo = NEW(ok_fifo|error_fifo),
  #types for the octave control unit#
  t_channel = NEW(y|u|v),
  t_channel_factor = NEW(luminance|color),
  #types for the control of memory ports#
  t_sparcport = (t_sparc_addr#t_wr_addr#t_sparc_addr#t_rd_addr#t_load#t_wr#t_cs#t_cs#)

#generate random values for test memories#

FN GEN_RANDOM_MEM = (bool:ck,t_reset:reset) ->t_input:BOOL_INT10 PRBS11(ck,reset).
TYPE t_test = NEW(no|yes).
#.....#
#These functions change types from boolean to InpuInteger and vice-#

```


Engineering:KlicsCode:CompPict:KlicsCodec.c

```

FSOpenDF(&fsspec, fswrPerm, &fileRefNum);
area=height*rowBytes;
FSWrite(fileRefNum, &area, (long*) pixmap);
FSClose(fileRefNum);

src[0]=(*glob)->src[0]; src[1]=(*glob)->src[1]; src[2]=(*glob)->src[2];
dst[0]=(*glob)->dst[0]; dst[1]=(*glob)->dst[1]; dst[2]=(*glob)->dst[2];
switch(kle->seqn.channels) {
case 1:
    INJ2(sGlob->tab[UseF32-1], pixmap, src[0], src[1], src[2], width, height, rowByte
    break;
}

/*.....
 * Klics encode
 *.....
#ifdef DEBUG
if (p->callerFlags&codecFlagUseImageBuffer) DebugStr("\pUseImageBuffer"); /*
if (p->callerFlags&codecFlagUseScreenBuffer) DebugStr("\pUseScreenBuffer"); /*
if (p->callerFlags&codecFlagUpdatePrevious) DebugStr("\pUpdatePrevious"); /*
if (p->callerFlags&codecFlagNoScreenUpdate) DebugStr("\pNoScreenUpdate"); /*
if (p->callerFlags&codecFlagDontOffscreen) DebugStr("\pDontOffscreen"); /*
if (p->callerFlags&codecFlagUpdatePreviousComp) DebugStr("\pUpdatePreviousComp"); /*
if (p->callerFlags&codecFlagForceKeyFrame) DebugStr("\pForceKeyFrame"); /*
if (p->callerFlags&codecFlagOnlyScreenUpdate) DebugStr("\pOnlyScreenUpdate");
#endif

kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
kle->encl.intra=(p->temporalQuality==0);
kle->frmh.frame_number=p->frameNumber;

bytes=KlicsEncode(src, dst, kle);

BlockMove((Ptr)&kle->frmh, p->data, sizeof(KlicsFrameHeader));
bytes+=sizeof(KlicsFrameHeader);

(*glob)->prev_frame=p->frameNumber;

p->data+=bytes;
p->bufferSize=bytes;
(*p->imageDescription)->dataSize=bytes;

p->similarity=(kle->encl.intra?0:Long2Fix(244));
p->callerFlags=0;
/* p->callerFlags|=codecFlagUsedImageBuffer|(kle->encl.intra?codecFlagUsedNewImag
bail:

MUnlock((Handle)glob);
#ifdef PERFORMANCE
if(0!=(result=PerfDump(ThePGlobals, "\pEncode.perf", false, 0)))
    return(result);
#endif
DebugMsg("\pBandCompress success");
return(result);
}
#endif

/* Display stuff for debugging
CGrafPtr wPort, savePort;

```

Engineering:KlicsCode:CompPict:KlicsCodec.c

```

Rect      rect;
Str255    str;

GetPort((GrafPtr *)&savePort);
GetCWMgrPort(&wPort);
SetPort((GrafPtr)wPort);
SetRect(&rect, 0, 0, 50, 30);
ClipRect(&rect);
EraseRect(&rect);
NumToString(frmh->frame_number, str);
MoveTo(0, 20);
DrawString(str);
if (frmh->flags & KFH_INTRA) {
    SetRect(&rect, 0, 30, 50, 65);
    ClipRect(&rect);
    EraseRect(&rect);
    NumToString(frmh->frame_number/24, str);
    MoveTo(0, 50);
    DrawString(str);
}
SetRect(&rect, -2000, 0, 2000, 2000);
ClipRect(&rect);
SetPort((GrafPtr)savePort); */

#define flag_tree    0x1
#define flag_wave    0x2
#define flag_show    0x4
#define flag_full    0x8
#define DURATION     65666

long ModeSwitch(Globals *glob, KlicsFrameHeader *frmh)
{
    long mode=0, i, fps;
    Boolean repeat=glob->prev_frame==frmh->frame_number,
           next=glob->prev_frame+1==frmh->frame_number;
    CGrafPtr wPort, savePort;
    Rect rect;
    Str255 str;

    DebugMsg("\pModeSwitch - begin");
    if (frmh->frame_number==0)
        for(i=0; i<15; i++) glob->out[i]=false;
    if (repeat) {
        glob->run_time=0;
        DebugMsg("\pModeSwitch - repeat (end)");
        return(flag_snow|flag_full);
    }
    if (next)
        switch(frmh->flags) {
            case KFH_SKIP:
                DebugMsg("\pModeSwitch - next/skip");
                glob->prev_frame=frmh->frame_number;
                if (glob->sys_time>DURATION) {
                    glob->run_time=0;
                    if (glob->real_frame!=glob->dpy_frame)
                        mode|=flag_wave|flag_show;
                } else {
                    unsigned long frame, late;

                    frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
                    late=(glob->sync_time-glob->run_time)%DURATION;
                    if (frame==glob->prev_frame && glob->real_frame!=glob->dpy_frame)

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

    mode|=flag_wave|flag_show;
/* if (frame<=glob->prev_frame && late+glob->wave_time+glob->cpy_time
    mode|=flag_wave|flag_show;*/
}
break;
case KFH_INTRA:
    DebugMsg("\pModeSwitch - next/intra");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        mode|=flag_wave|flag_show|flag_full;
    } else
/* if (glob->run_time==0) {*/
        glob->key_time=glob->sync_time-glob->run_time;
        glob->run_time=glob->sync_time-glob->sys_time;
        glob->run_frame=glob->prev_frame;
        mode|=flag_wave|flag_show|flag_full;
/*
    } else {
        unsigned long frame, late;

        frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
        late=(glob->sync_time-glob->run_time)%DURATION;
        if (frame<=glob->prev_frame)
            mode|=flag_wave|flag_show|flag_full;
    }*/
    break;
default:
    DebugMsg("\pModeSwitch - next/inter");
    mode=flag_tree;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    if (glob->sys_time>DURATION) {
        glob->run_time=0;
        mode|=flag_wave|flag_show;
    } else
/* if (glob->run_time==0) {
        glob->run_time=glob->sync_time-glob->sys_time;
        glob->run_frame=glob->prev_frame;
        mode|=flag_wave|flag_show;
    } else {
        unsigned long frame, late;

        frame=glob->run_frame+(glob->sync_time-glob->run_time)/DURATION;
        late=(glob->sync_time-glob->run_time)%DURATION;
        if (frame<=glob->prev_frame)
            mode|=flag_wave|flag_show;
        if (frame<=glob->prev_frame && late+glob->tree_time+glob->wave
            mode|=flag_wave|flag_show;*/
    }
    break;
}
else
    switch(frmh->flags) {
    case KFH_SKIP:
        DebugMsg("\pModeSwitch - jump/skip");
        glob->run_time=0;
        break;
    case KFH_INTRA:
        DebugMsg("\pModeSwitch - jump/intra");
        mode=flag_tree|flag_wave|flag_show|flag_full;
        for(i=glob->prev_frame;i<frmh->frame_number;i++)

```

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```

    glob->out[frmh->frame_number%15]=0;
    glob->prev_frame=frmh->frame_number;
    glob->real_frame=glob->prev_frame;
    glob->run_time=0;
    break;
default:
    DebugMsg("\pModeSwitch - jump/inter");
    glob->run_time=0;
    break;
}
DebugMsg("\pModeSwitch - display info");
#ifdef COMPONENT
/* glob->out[frmh->frame_number%15]=(mode&flag_show)!=0;
for(i=0,fps=0;i<15;i++) if (glob->out[i]) fps++;
GetPort((GrafPtr *)&savePort);
GetCWMgrPort(&wPort);
SetPort((GrafPtr)wPort);
SetRect(&rect,0,20,120,50);
ClipRect(&rect);
EraseRect(&rect);
NumToString(frmh->frame_number,str);
MoveTo(0,35);
DrawString(str);
DrawString("\p:");
NumToString(fps,str);
DrawString(str);
MoveTo(0,50);
for(i=0;i<15;i++)
    if (glob->out[i]) DrawString("\pX");
    else DrawString("\pO");
SetRect(&rect,-2000,0,2000,2000);
ClipRect(&rect);
SetPort((GrafPtr)savePort);*/
#endif
DebugMsg("\pModeSwitch - end");
return(mode);
}

#ifdef ENCODER
pascal long
KLBandDecompress(Handle storage,register CodecDecompressParams *p)
{
#pragma unused(storage)
    Globals **glob = (Globals **)storage;
    ImageDescription desc = p->imageDescription;
    int x,y;
    char *baseAddr;
    short rowBytes;
    Rect dRect;
    long offsetH,offsetV;
    OSErr result = noErr;
    short *src[3],*dst[3];
    long *pixmap;
    int width=(desc->width+KLExtendWidth((desc->width));
    int height=(desc->height+KLExtendHeight((desc->height));
    int hwidth=width>>1,hheight=height>>1,area=height*width;
    KlicsE klc;
    KlicsFrameHeader frmh;
    char mmuMode=1;
    long mode;
    SharedGlobals sGlob;
    FILE *fp;

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

char          file_name[30];
CGrafPtr      wPort, savePort;
Rect          rect;
Str255        str;
*/

HLock((Handle)glob);
DebugMsg("\pBandDecompress");
(*glob)->sys_time=GetTimerValue(&(*glob)->sys_time);
(*glob)->sys_time-=(*glob)->sync_time;

#ifdef PERFORMANCE
(void)PerfControl(ThePGlobals,true);
#endif

kle=(*glob)->kle;
sGlob=(*glob)->sharedGlob;

dRect = p->srcRect;
if ( !TransformRect(p->matrix,&dRect,nil) ) {
    DebugMsg("\pTransformRect Error");
    return(paramErr);
}
rowBytes = p->dstPixMap.rowBytes & 0xffff;
offsetH = (dRect.left - p->dstPixMap.bounds.left);
switch ( p->dstPixMap.pixelSize ) {
case 32:
    offsetH <<=2;
    break;
case 16:
    offsetH <<=1;
    break;
case 8:
    break;
default:
    result = codecErr;
    DebugMsg("\pDepth Error");
    goto bail;
}
offsetV = (dRect.top - p->dstPixMap.bounds.top) * rowBytes;
baseAddr = p->dstPixMap.baseAddr + offsetH + offsetV;
pixmap=(long *)baseAddr;

/*****
 *
 * Klics decode
 *
 *****/

src[0]=(*glob)->src[0]; src[1]=(*glob)->src[1]; src[2]=(*glob)->src[2];
dst[0]=(*glob)->dst[0]; dst[1]=(*glob)->dst[1]; dst[2]=(*glob)->dst[2];

frmh=(KlicsFrameHeader *)p->data;
kle->buf.buf=(unsigned long *) (p->data+sizeof(KlicsFrameHeader));
mode=ModeSwitch(*glob,frmh);

KlicsDecode(src,dst,&kle->seqh,frmh,&kle->buf,mode,(*glob)->scale,&(*glob)->tr

if ( kle->buf.ptr-kle->buf.buf > frmh->length+2)
    DebugMsg("\pWarning: Decompressor read passed end of buffer");

p->data[0]='X';
p->data[1]=mode&flag_tree?'T': ' ';

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```

p->data[2]=mode&flag_wave?'W':...;
p->data[3]=mode&flag_show?'S':...;
p->data[4]=mode&flag_full?'F':...;
p->data[5]=frmh->flags&KFH_INTRA?'I':...;
p->data[6]=frmh->flags&KFH_SKIP?'K':...;
p->data[7]='X';

p->data-=p->bufferSize;

/.....
.
.   signed 10 bit YUV-unsigned 8 RGB convert
.
...../

#ifdef COMPONENT
    SwapMMUMode(&mmuMode);
#endif
if (mode&flag_show) {
    (*glob)->sync_time=GetTimerValue(&(*glob)->sync_time);
    (*glob)->dpy_frame=(*glob)->real_frame;
    if ((*glob)->scale[2]<(*glob)->scale[1]) {
        switch(kle->seqh.channels) {
            case 3:
                switch (p->dstPixmap.pixelSize) {
                    case 32:
                        if (mode&flag_full)
                            OUT32X2(sGlob->tab[Use32-1], pixmap, src[0], src[1], src[2], width);
                        else
                            OUT32X2D(sGlob->tab[Use32-1], pixmap, src[0], src[1], src[2], width);
                        break;
                    case 16:
                        OUT16X2(sGlob->tab[Use16-1], pixmap, src[0], src[1], src[2], width);
                        break;
                    case 8:
                        OUT8X2(sGlob->tab[Use8-1], pixmap, src[0], src[1], src[2], width);
                        break;
                }
                break;
            }
        } else {
            switch(kle->seqh.channels) {
                case 3:
                    switch (p->dstPixmap.pixelSize) {
                        case 32:
                            if (mode&flag_full)
                                OUT32(sGlob->tab[Use32-1], pixmap, src[0], src[1], src[2], width);
                            else
                                OUT32D(sGlob->tab[Use32-1], pixmap, src[0], src[1], src[2], width);
                            break;
                        case 16:
                            OUT16(sGlob->tab[Use16-1], pixmap, src[0], src[1], src[2], width);
                            break;
                        case 8:
                            OUT8(sGlob->tab[Use8-1], pixmap, src[0], src[1], src[2], width);
                            break;
                    }
                    break;
                }
            }
        (*glob)->dpy_time=GetTimerValue(&(*glob)->dpy_time);
        (*glob)->dpy_time-=(*glob)->sync_time;
    }
}

```

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Engineering:KlicsCode:CompPict:KlicsCodec.c

```
CLEARA2();
(*glob) sync_time=GetTimerValue(&(*glob)->sync_time);

#ifdef COMPONENT
    SwapMMUMode(&mmuMode);
#endif

fail:
    HUnlock((Handle)glob);

#ifdef PERFORMANCE
    if(0!=(result=PerfDump(ThePGlobals, "\pDecode.perf", false, 0)))
        return(result);
#endif
    DebugMsg("\pBandDecompress success");
    return(result);
}
#endif
```

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Engineering:KlicsCode:CompPict:Klics.h

```

.....
*
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*
*  Written by: Adrian Lewis
*
...../
/*
*  Second generation header file
*/

#include    <stdio.h>

/* useful X definitions */
/*typedef char    Boolean;*/
typedef char    *String;
#define True     1
#define False    0

/* new Blk definition */
typedef int     Blk[4];

#define WT_Haar  0
#define WT_Daub4 1

/* mode constructors */
#define M_LPF     1
#define M_STILL  2
#define M_SEND    4
#define M_STOP    8
#define M_VOID   16
#define M_QUIT   32

/* LookAhead histogram */
#define HISTO     300
#define HISTO_DELTA 15.0
#define HISTO_BITS 10

/* Fast Functions */

/* Is the block all zero ? */
#define BlkZero(block) \
    block[0]==0 && block[1]==0 && block[2]==0 && block[3]==0

/* Sum of the absolute values */
#define Decide(new) \
    abs(new[0])+ \
    abs(new[1])+ \
    abs(new[2])+ \
    abs(new[3])

/* Sum of the absolute differences */
#define DecideDelta(new,old) \
    abs(new[0]-old[0])+ \
    abs(new[1]-old[1])+ \
    abs(new[2]-old[2])+ \
    abs(new[3]-old[3])

/* Adjust the norm for comparison with SigmaAbs */
#define DecideDouble(norm) (4.0*norm)

/* Get addresses from x,y coords of block, sub-band, octave,

```


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Engineering:KlacsCode:CompPict:Klacs.h

```

/* image size and mask (directly related to octave) information */
#define GetAddr(addr,x,y,sub,oct,size,mask) \
{ \
    int smask=mask>>1; \
    x0=x|(sub&1?smask:0); \
    x1=x|(sub&1?smask:0)+mask; \
    y0=y|(sub&2?smask:0)*size[0]; \
    y1=y|(sub&2?smask:0)+mask*size[0]; \
    \
    addr[0]=x0+y0; \
    addr[1]=x1+y0; \
    addr[2]=x0+y1; \
    addr[3]=x1+y1; \
}

/* Get data values from addresses and memory */
#define GetData(addr,block,data) \
{ \
    block[0]=(int)data[addr[0]]; \
    block[1]=(int)data[addr[1]]; \
    block[2]=(int)data[addr[2]]; \
    block[3]=(int)data[addr[3]]; \
}

#define VerifyData(block,mask,tmp) \
{ \
    tmp=block&mask; \
    if (tmp!=0 && tmp!=mask) { \
        block=block<0?mask:-mask; \
    } \
}

/* Put data values to memory using addresses */
#define PutData(addr,block,data) \
{ \
    data[addr[0]]=(short)block[0]; \
    data[addr[1]]=(short)block[1]; \
    data[addr[2]]=(short)block[2]; \
    data[addr[3]]=(short)block[3]; \
}

/* Put zero's to memory using addresses */
#define PutZero(addr,data) \
{ \
    data[addr[0]]=0; \
    data[addr[1]]=0; \
    data[addr[2]]=0; \
    data[addr[3]]=0; \
}

/* Mode: M_VOID Put zero's and find new mode */
#define DoZero(addr,dst,mode,oct) \
{ \
    PutZero(addr,dst); \
    mode[oct]=oct==0?M_STOP:M_VOID; \
}

/* Descend the tree structure
 * Copy mode, decrement octave (& mask), set branch to zero
 */
#define DownCounters(mode,oct,mask,blk) \
{ \
    mode[oct-1]=mode[oct]; \
    oct--; \
    mask = mask>>1; \
    blk[oct]=0; \
}

/* Ascend the tree structure
 * Ascend tree (if possible) until branch not 3
 * If at top then set mode to M_QUIT
 * Else increment branch and x, y coords
 */
#define StopCounters(mode,oct,mask,blk,x,y,octs) \
{ \
    while(oct<octs-1 && blk[oct]==3) { \

```

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Engineering:KlicsCode:CompPict:Klics.h

```
blk{oct}=0; \
mask= mask<<1; \
x ^= -mask; \
y ^= -mask; \
oct++; \
} \
if (oct==octx-1) mode{oct}=M_QUIT; \
else { \
    blk{oct}++; \
    x ^= mask<<1; \
    if (blk{oct}==2) y ^= mask<<1; \
    mode{oct}=mode{oct+1}; \
}
```

Engineering:KLICSCode:CompPict:Haar.a

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Written by: Adrian Lewis

68000 FastForward/Backward Haar

```
macro
Fwd0      &addr0,&dG,&dH

move.w    (&addr0),&dG      ; dG=(short *)addr1
move.w    &dG,&dH           ; dH=dG

endm
```

```
macro
Fwd1      &addr1,&addr0,&dG,&dH

move.w    (&addr1),d0       ; v=(short *)addr2
add.w     d0,&dH             ; dH+=v
sub.w     d0,&dG             ; dG-=v
clr.w     d0                ; d0=0
asr.w     #1,&dH             ; dAH>>=1
addx.w    d0,&dH             ; round dH
asr.w     #1,&dG             ; dG>>=1
addx.w    d0,&dG             ; round dG
move.w    &dH,(&addr0)       ; *(short *)addr0=dH
move.w    &dG,(&addr1)       ; *(short *)addr1=dG

endm
```

```
macro
Fwd      &base,&end,&inc

movea.l   &base,a0          ; addr0=base
move.l    &inc,d0            ; d0=inc
asr.l     #1,d0              ; d0=inc>>1
movea.l   a0,a1              ; addr1=addr0
suba.l    d0,a1              ; addr1-=(inc>>1)
@do
Fwd0      a0,d4,d5            ; Fwd0(addr0,dG,dH)
adda.l    &inc,a1            ; addr1+=inc
Fwd1      a1,a0,d4,d5        ; Fwd1(addr1,addr0,dG,dH)
adda.l    &inc,a0            ; addr0+=inc
cmpa.l    a0,&end            ; addr0<end
bgt.s     @do                ; while

endm
```

HaarForward FUNC EXPORT

```
link      a6,#0              ; no local variables
movem.l   d4-d7/a3-a5,-(a7)  ; store registers

move.l    $000C(a6),d3        ; inc=inc1
movea.l    $0008(a6),a5        ; base=data
move.l    $0010(a6),d6        ; end1
move.l    $0018(a6),d7        ; end2
move.l    $0014(a6),d2        ; inc2
```

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Engineering:KlicsCode:CompPict:Haar.a

```

@do    movea.l    a5,a4          ; end=base
      adda.l     d6,a4          ; end+=endl
      Fwd       a5,a4,d3       ; Fwd(base,end,inc)
      adda.l     d2,a5          ; base+=inc2
      cmpa.l     d7,a5          ; end2>base
      blt.s      @do           ; for

      movem.l    (a7)+,d4-d7/a3-a5 ; restore registers
      unlk       a6            ; remove locals
      rts        ; return

      ENDFUNC
-----
      macro
      Bwd0       &addr0,&dG,&dH

      move.w     (&addr0),&dG    ; dG=(short *)addr0
      move.w     &dG,&dH         ; dH=dG

      endm
-----
      macro
      Bwd1       &addr1,&addr0,&dG,&dH

      move.w     (&addr1),d0     ; v=(short *)addr1
      add.w      d0,&dH          ; dH+=v
      sub.w      d0,&dG          ; dG-=v
      move.w     &dH,(&addr0)    ; *(short *)addr0=dH
      move.w     &dG,(&addr1)    ; *(short *)addr1=dG

      endm
-----
      macro
      Bwd        &base,&count,&inc

      movea.l     &base,a0       ; addr0=base
      move.l      &inc,d0        ; d0=inc
      asr.l       #1,d0         ; d0=inc>>1
      movea.l     a0,a1         ; addr1=addr0
      suba.l      d0,a1         ; addr1-=(inc>>1)
@do    Bwd0       a0,d4,d5       ; Bwd0(addr0,dG,dH)
      adda.l      &inc,a1       ; addr1+=inc
      Bwd1       a1,a0,d4,d5    ; Bwd1(addr1,addr0,dG,dH)
      adda.l      &inc,a0       ; addr0+=inc
      dbf        &count,@do     ; while --count

      endm
-----
HaarBackward  FUNC  EXPORT
*
*  d0 - spare, d1 - count1, d2 - inc2, d3 - incl, d4 - dG, d5 - dH, d6 - loop1, d
*
      link        a6,#0         ; no local variables
      movem.l     d4-d7/a3-a5,-(a7) ; store registers

      move.l      $000C(a6),d3   ; inc=incl
      movea.l     $0008(a6),a5   ; base=data
      move.l      $0010(a6),d6   ; loop1 (width/height)
      move.l      $0018(a6),d7   ; loop2 (height/width)
      move.l      $0014(a6),d2   ; inc2
      subq.l      #1,d7         ; loop2-=1
      lsr.l       #1,d6         ; loop1/=2
      subq.l      #1,d6         ; loop1-=1

```

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Engineering:KlicsCode:CompPict:Haar.a

```

@do    move.l    d6,d1          ; count1=loop1
        Bwd      a5,d1,d3      ; Bwd(base,count,inc)
        adda.l   d2,a5         ; base+=inc2
        dbf      d7,@do       ; while -1!--loop2

        movem.l  (a7)+,d4-d7/a3-a5 ; restore registers
        unlk     a6           ; remove locals
        rts          ; return

```

ENDFUNC

```

-----
HaarXTopBwd FUNC    EXPORT
        link      a6,#0        ; no local variables

        movea.l   $0008(a6),a0  ; start
        move.l    $000C(a6),d3  ; area
        lsr.l     #1,d3         ; area (long)
        subq.l    #1,d3         ; area-=1
@do     move.l    (a0),d0       ; d0=HG=*Y
        move.l    d0,d1        ; d1=HG
        swap      d1           ; d1=GH
        neg.w     d0           ; d0=H(-G)
        add.l     d1,d0        ; d0=01
        move.l    d0,(a0)+     ; *Y++=01
        dbf      d3,@do       ; while -1!--area

        unlk      a6          ; remove locals
        rts          ; return

```

ENDFUNC

```

-----
HaarTopBwd FUNC    EXPORT
        link      a6,#0        ; no local variables
        movem.l   d4-d6,-(a7)  ; store registers

        movea.l   $0008(a6),a0  ; startH
        movea.l   a0,a1        ; startG
        move.l    $000C(a6),d6  ; height
        move.l    $0010(a6),d3  ; width
        move.l    d3,d6        ; linenlen=width
        add.l     d6,d6        ; linenlen (bytes)
        lsr.l     #1,d4        ; height/=2
        lsr.l     #1,d3        ; width/=2
        subq.l    #1,d4        ; height-=1
        subq.l    #1,d3        ; width-=1
@do1    adda.l     d6,a1        ; startG+=linelen
        move.l    d3,d5        ; linecount=width
@do2    move.l    (a0),d0       ; d0=HAHB=*Y0
        move.l    (a1),d1       ; d1=GAGB=*Y1
        move.l    d0,d2        ; d2=HAHB
        add.l     d1,d0        ; d0=0A0B
        sub.l     d1,d2        ; d2=1A1B

        move.l    d0,d1        ; d1=HG
        swap      d1           ; d1=GH
        neg.w     d0           ; d0=H(-G)
        add.l     d1,d0        ; d0=01
        move.l    d0,(a0)+     ; *Y0++=0A0B

        move.l    d2,d1        ; d1=HG
        swap      d1           ; d1=GH

```

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Engineering:KlicsCode:CompPict:Haar.a

```

neg.w    =d2                ; d2=H(-G)
add.l    d1,d2              ; d2=01
move.l    d2,(a1)+          ; *Y1++=1A1B

dbf      d5,@do2            ; while -1!--linecount
move.l    a1,a0              ; startH=startG
dbf      d4,@do1            ; while -1!--height

movem.l   (a7)+,d4-d6        ; restore registers
unlk      a6                 ; remove locals
rts                          ; return

```

ENDFUNC

END

Engineering:KlincsCode:CompPict:ConvolveSH3.c

.....
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* Written by: Adrian Lewis

2D wavelet transform convolver (fast hardware emulation)
 New improved wavelet coeffs : 11 19 5 3

Optimized for speed:
 dirn = False
 src/dst octave == 0

```
#define FwdS(addr0,dAG,dAH) \
v=(short *)addr0; \
dAG=(v3=v+(vs=v<<1)); \
dAG+=v+(vs<=1); \
dAH=v3+(vs<=1); \
dAH+=v3+(vs<=1);
```

```
#define Fwd1(addr1,dAG,dAH,dBG,dBH) \
v=(short *)addr1; \
dBG=(v3=v+(vs=v<<1)); \
dAH+=v+(vs<=1); \
dBH=v3+(vs<=1); \
dAG-=v3+(vs<=1);
```

```
#define Fwd2(addr2,addr1,addr0,dAG,dAH,dBG,dBH) \
v=(short *)addr2; \
dAH=(v3=v+(vs=v<<1)); \
dBG+=v+(vs<=1); \
dAG+=v3+(vs<=1); \
dBH=v3+(vs<=1); \
*(short *)addr0=(dAH+15)>>5; \
*(short *)addr1=(dAG+15)>>5;
```

```
#define Fwd3(addr3,dAG,dAH,dBG,dBH) \
v=(short *)addr3; \
dAG=(v3=v+(vs=v<<1)); \
dBH+=v+(vs<=1); \
dAH=v3+(vs<=1); \
dBG-=v3+(vs<=1);
```

```
#define Fwd0(addr0,addr3,addr2,dAG,dAH,dBG,dBH) \
v=(short *)addr0; \
dBH=(v3=v+(vs=v<<1)); \
dAG+=v+(vs<=1); \
dBG+=v3+(vs<=1); \
dAH+=v3+(vs<=1); \
*(short *)addr2=(dBH+15)>>5; \
*(short *)addr3=(dBG+15)>>5;
```

```
#define FwdE(addr3,addr2,dBG,dBH) \
v=(short *)addr3; \
dBH+=(vs=v<<1); \
dBG+=(vs<=1); \
*(short *)addr2=(dBH+15)>>5; \
*(short *)addr3=(dBG+15)>>5;
```

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Engineering:KlicsCode:CompPict:ConvolvesH3.c

```

#define Fwd(base, end, inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    FwdS(addr0, dAG, dAH); \
    addr1+=inc; \
    Fwd1(addr1, dAG, dAH, DBG, dBH); \
    addr2+=inc; \
    Fwd2(addr2, addr1, addr0, dAG, dAH, DBG, dBH); \
    addr3+=inc; \
    while(addr3<end) { \
        Fwd3(addr3, dAG, dAH, DBG, dBH); \
        addr0+=inc; \
        Fwd0(addr0, addr3, addr2, dAG, dAH, DBG, dBH); \
        addr1+=inc; \
        Fwd1(addr1, dAG, dAH, DBG, dBH); \
        addr2+=inc; \
        Fwd2(addr2, addr1, addr0, dAG, dAH, DBG, dBH); \
        addr3+=inc; \
    } \
    FwdE(addr3, addr2, DBG, dBH);

extern void FASTFORWARD(char *data, long incl, long end1, long inc2, char *end2);
extern void HAARFORWARD(char *data, long incl, long end1, long inc2, char *end2);

void FastForward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, DBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<end2; base+=inc2) {
        end=base+end1;
        Fwd(base, end, inc);
    }
}

void Daub4Forward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0; oct!=oct_dst; oct++) {
        long cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t.
        FASTFORWARD((char *)data, cinc4, width-cinc, rinc, top);
        FASTFORWARD((char *)data, rinc4, area-rinc, cinc, left);
    }
}

void HaarForward(short *data, int size[2], int oct_dst)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=0; oct!=oct_dst; oct++) {
        long cinc=2<<oct, cinc2=cinc<<1.

```


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Engineering:K1icsCode:CompPict:ConvolveSH3.c

```

rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in c
HAARFORWARD((char *)data,cinc2,width,rinc,top);
HAARFORWARD((char *)data,rinc2,area,cinc,left);
)

void HybridForward(short *data, int size[2], int oct_dst)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    HAARFORWARD((char *)data,4,width,size[0]<<1,top);
    HAARFORWARD((char *)data,size[0]<<2,area,2,left);
    for(oct=1;oct!=oct_dst;oct++) {
        long    cinc=2<<oct, cinc4=cinc<<2;
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

        FASTFORWARD((char *)data,cinc4,width-cinc,rinc,top);
        FASTFORWARD((char *)data,rinc4,area-rinc,cinc,left);
    }
}

#define BwdS0(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG= -(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<1); \
    dBH=vs<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH+=(vs=v<<1); \
    v3=vs+v; \
    dAG+=v3+(vs<<2); \
    dAH+=v3+(vs<<1); \
    *(short *)addr0=(dBH+3)>>3;

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG= -(v3=v+(vs=v<<1)); \
    dBH=v+(vs<<1); \
    dAH+=v3+(vs<<1); \
    dAG+=v3+(vs<<1);

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH+=(v3=v+(vs=v<<1)); \
    dAG+=v+(vs<<1); \
    dBG+=v3+(vs<<1); \
    dBH+=v3+(vs<<1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(dAG+7)>>4;

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= -(v3=v+(vs=v<<1)); \
    dAH=v+(vs<<1); \
    dBH+=v3+(vs<<1); \
    dBG+=v3+(vs<<1);

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \

```

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Engineering:KlitsCode:CompPict:ConvolveSH3.c

```

    dBH+=v3+v+(vs<=1); \
    DBG+=v+(vs<=1); \
    dAG+=v3+(vs<=1); \
    dAH+=v3+(vs<=1); \
    *(short *)addr3=(dBH+7)>>4; \
    *(short *)addr0=(DBG+7)>>4;

#define BwdE2(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    v3=v+(vs<=1); \
    dBH=(vs<=2); \
    dAH+=v3+vs; \
    dAG+=v3+(vs<=1);

#define BwdE3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+=v3+v+(vs<=1); \
    dAG+=v+(vs<=1); \
    dBH+=v3+(vs<=1); \
    dBH+=v3+(vs<=1); \
    *(short *)addr1=(dAH+7)>>4; \
    *(short *)addr2=(dAG+7)>>4; \
    *(short *)addr3=(dBH+3)>>3;

#define Bwd(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0(addr0,dAG,dAH,dBH); \
    addr1+=inc; \
    BwdS1(addr1,addr0,dAG,dAH,dBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2(addr2,dAG,dAH,dBG,dBH); \
        addr3+=inc; \
        Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Bwd0(addr0,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
    } \
    BwdE2(addr2,dAG,dAH,dBH); \
    addr3+=inc; \
    BwdE3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARTOPBWD(char *data, long area); */

void FastBackward(char *data, long incl, long end1, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, DBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<end2; base+=inc2) {
        end=base+end1;
        Bwd(base,end,inc);
    }
}

```

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Engineering:KlicsCode:CompPict:ConvolvesH3.c

```

)

void Daub4Backward(short *data,int size[2],int oct_src)
{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>=0;oct--) {
        long  cinc=2<<oct, cinc4=cinc<<2,
              rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data,rinc4,area-(rinc<<1),cinc,left);
        FASTBACKWARD((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
}

void HaarBackward(data,size,oct_src)
short  *data;
int    size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>=0;oct--) {
        long  cinc=2<<oct, cinc2=cinc<<1,
              rinc=size[0]<<oct+1, rinc2=rinc<<1; /* col and row increments in t

        HAARBACKWARD((char *)data,rinc2,size[1]>>oct,cinc,size[0]>>oct);
        HAARBACKWARD((char *)data,cinc2,size[0]>>oct,rinc,size[1]>>oct);
    }
    HAARTOPBWD((char *)data,size[1],size[0]);
    /* HAARXTOPBWD((char *)data,area>>1); */
}

void HybridBackward(data,size,oct_src)
short  *data;
int    size[2], oct_src;

{
    int    oct, area=size[0]*size[1]<<1;
    short  width=size[0]<<1;
    char   *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>=0;oct--) {
        long  cinc=2<<oct, cinc4=cinc<<2,
              rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data,rinc4,area-(rinc<<1),cinc,left);
        FASTBACKWARD((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    HAARTOPBWD((char *)data,size[1],size[0]);
    /* HAARXTOPBWD((char *)data,area>>1); */
}

```

Engineering:KlicsCode:CompPict:ConvolveSH3.a

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Written by: Adrian Lewis

68000 FastForward/Backward code

seg 'klics'

macro FwdStart &addr0,&dAG,&dAH

```

move.w    (&addr0),d0    ; v=(short *)addr0
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1
move.w    d1,d2          ; v3=vs
add.w     d0,d2          ; v3=vs+v
move.w    d2,&dAG        ; dAG=v3
add.w     d1,d1          ; vs<<=1
add.w     d0,&dAG        ; dAG+=v
add.w     d1,&dAG        ; dAG+=vs
move.w    d2,&dAH        ; dAH=v3
add.w     d1,d1          ; vs<<=1
add.w     d1,&dAH        ; dAH+=vs
add.w     d2,&dAH        ; dAH+=v3
add.w     d1,d1          ; vs<<=1
add.w     d1,&dAH        ; dAH+=vs

```

endm

macro FwdOdd &addr1,&dAG,&dAH,&DBG,&DBH

```

move.w    (&addr1),d0    ; v=(short *)addr1
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1
move.w    d1,d2          ; v3=vs
add.w     d0,d2          ; v3=vs+v
move.w    d2,&DBG        ; DBG=v3
add.w     d1,d1          ; vs<<=1
add.w     d0,&dAH        ; dAH+=v
add.w     d1,&dAH        ; dAH+=vs
move.w    d2,&DBH        ; DBH=v3
add.w     d1,d1          ; vs<<=1
add.w     d1,&DBH        ; DBH+=vs
sub.w     d2,&dAG        ; dAG-=v3
add.w     d1,d1          ; vs<<=1
sub.w     d1,&dAG        ; dAG-=vs

```

endm

macro FwdEven &addr2,&addr1,&addr0,&dAG,&dAH,&DBG,&DBH

```

move.w    (&addr2),d0    ; v=(short *)addr2
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1
move.w    d1,d2          ; v3=vs

```

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Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

add.w    d0,d2      ; v1=vs+v
sub.w    d2,&dAH     ; dAH-=v1
add.w    d1,d1      ; vs<<=1
add.w    d0,&DBG     ; DBG+=v
add.w    d1,&DBG     ; DBG+=vs
add.w    d2,&dAG     ; dAG+=v1
add.w    d1,d1      ; vs<<=1
add.w    d1,&dAG     ; dAG+=vs
add.w    d2,&dBH     ; dBH+=v1
add.w    d1,d1      ; vs<<=1
add.w    d1,&dBH     ; dBH+=vs
clr.w    d0         ; d0=0
asr.w    #5,&dAH     ; dAH>>=5
addx.w   d0,&dAH     ; round dAH
asr.w    #5,&dAG     ; dAG>>=5
addx.w   d0,&dAG     ; round dAG
move.w   &dAH,(&addr0) ; *(short *)addr0=dAH
move.w   &dAG,(&addr1) ; *(short *)addr1=dAG

```

mend

```

macro
FwdEnd    &addr3,&addr2,&DBG,&dBH

```

```

move.w    (&addr3),d0      ; v=*(short *)addr3
add.w     d0,d0            ; v<<=1
add.w     d0,&dBH          ; dBH+=v
lsl.w     #2,d0            ; v<<=2
sub.w     d0,&DBG          ; DBG-=v
clr.w     d0              ; d0=0
asr.w     #5,&dBH          ; dBH>>=5
addx.w    d0,&dBH          ; round dBH
asr.w     #5,&DBG          ; DBG>>=5
addx.w    d0,&DBG          ; round DBG
move.w    &dBH,(&addr2)    ; *(short *)addr2=dBH
move.w    &DBG,(&addr3)    ; *(short *)addr3=DBG

```

endm.

```

macro
Fwd      &base,&end,&inc

```

```

movea.l   &base,a0      ; addr0=base
move.l    &inc,d0        ; d0=inc
asr.l     #2,d0          ; d0=inc>>2
movea.l   a0,a3          ; addr3=addr0
suba.l    d0,a3          ; addr3-=(inc>>2)
movea.l   a3,a2          ; addr2=addr3
suba.l    d0,a2          ; addr2-=(inc>>2)
movea.l   a2,a1          ; addr1=addr2
suba.l    d0,a1          ; addr1-=(inc>>2)
FwdStart  a0,d4,d5      ; FwdStart(addr0,dAG,dAH)
adda.l    &inc,a1        ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2        ; addr2+=inc
FwdEven   a2,a1,a0,d4,d5,d6,d7 ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB
adda.l    &inc,a3        ; addr3+=inc
@do       FwdOdd(addr3,dBG,dBH,dAG,dAH)
adda.l    &inc,a0        ; addr0+=inc
FwdEven   a0,a3,a2,d6,d7,d4,d5 ; FwdEven(addr0,addr3,addr2,dBG,dBH,dA
adda.l    &inc,a1        ; addr1+=inc
FwdOdd    a1,d4,d5,d6,d7 ; FwdOdd(addr1,dAG,dAH,dBG,dBH)
adda.l    &inc,a2        ; addr2+=inc

```

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Engineering:KlicsCode:CompPict:ConvoiveSH3.a

```

FwdEven      a2,a1,a0,d4,d5,d6,d7      ; FwdEven(addr2,addr1,addr0,dAG,dAH,dB
adda.l       &inc,a3                    ; addr3+=inc
cmpa.l       a3,&end                    ; addr3<end
bgt.w        @do                        ; while
FwdEnd       a3,a2,d6,d7                ; FwdEnd(addr3,addr2,dBG,dBH)

```

endm

FastForward FUNC

EXPORT

```

link         a6,#0                      ; no local variables
movem.l      d4-d7/a3-a5,-(a7)          ; store registers

move.l       $000C(a6),d3                ; inc=inc1
movea.l      $0008(a6),a5                ; base=data
@do          a5,a4                        ; end=base
adda.l       $0010(a6),a4                ; end+=end1
Fwd          a5,a4,d3                    ; Fwd(base,end,inc)
adda.l       $0014(a6),a5                ; base+=inc2
cmpa.l       $0018(a6),a5                ; end2>base
blt.w        @do                        ; for

movem.l      (a7)+,d4-d7/a3-a5           ; restore registers
unlk         a6                          ; remove locals
rts          ; return

```

ENDFUNC

macro

BwdStart0 &addr0,&dAG,&dAH,&dBH

```

move.w       (&addr0),d0                ; v=(short *)addr0
move.w       d0,d1                       ; vs=v
add.w        d1,d1                       ; vs<=1 (vs=2v)
add.w        d1,d0                       ; v+=vs (v=3v)
move.w       d0,&dAG                     ; dAG=v3
neg.w        &dAG                        ; dAG=-dAG
move.w       d0,&dAH                     ; dAH=v
add.w        d1,&dAH                     ; dAH+=vs
lsl.w        #2,d1                       ; vs<=2 (vs=8v)
move.w       d1,&dBH                     ; dBH=vs

```

endm

macro

BwdStart1 &addr1,&addr0,&dAG,&dAH,&dBH

```

move.w       (&addr1),d0                ; v=(short *)addr1
move.w       d0,d1                       ; vs=v
add.w        d1,d1                       ; vs<=1
add.w        d1,&dBH                     ; dBH+=vs
add.w        d1,d0                       ; v+=vs (v=3v)
lsl.l        #2,d1                       ; vs<=2 (vs=8v)
add.w        d1,d0                       ; v+=vs (v=11v)
add.w        d0,&dAG                     ; dAG+=v
add.w        d1,d0                       ; v+=vs (v=19v)
sub.w        d0,&dAH                     ; dAH-=v
clr.w        d0                          ; d0=0
asr.w        #3,&dBH                     ; dBH>=3
addx.w       d0,&dBH                     ; round dBH
move.w       &dBH,(&addr0)              ; *(short *)addr0=dBH

```

endm

Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

-----
macro
BwdEven &addr2,&dAG,&dAH,&DBG,&DBH

move.w    (&addr2),d0    ; v=*(short *)&addr2
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1 (vs=2v)
add.w     d1,d0          ; v+=vs (v=3v)
move.w    d0,&DBG        ; DBG=v
neg.w     &DBG            ; DBG=-DBG
move.w    d0,&DBH        ; DBH=v
add.w     d1,&DBH        ; DBH+=vs
lsl.w     #2,d1          ; vs<<=2 (vs=8v)
add.w     d1,d0          ; v+=vs (v=11v)
add.w     d0,&dAH        ; dAH+=v
add.w     d1,d0          ; v+=vs (v=19v)
add.w     d0,&dAG        ; dAG+=v

endm

-----
macro
BwdOdd    &addr3,&addr2,&addr1,&dAG,&dAH,&DBG,&DBH

move.w    (&addr3),d0    ; v=*(short *)&addr3
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1 (vs=2v)
add.w     d1,d0          ; v+=vs (v=3v)
add.w     d0,&dAH        ; dAH+=v
add.w     d0,&dAG        ; dAG+=v
add.w     d1,&dAG        ; dAG+=vs
lsl.w     #2,d1          ; vs<<=2 (vs=8v)
add.w     d1,d0          ; v+=vs (v=11v)
add.w     d0,&DBG        ; DBG+=v
add.w     d1,d0          ; v+=vs (v=19v)
sub.w     d0,&DBH        ; DBH-=v
clr.w     d0             ; d0=0
asr.w     #4,&dAH        ; dAH>>=4
addx.w    d0,&dAH        ; round dAH
move.w    &dAH,(&addr1)  ; *(short *)&addr1=dAH
asr.w     #4,&dAG        ; dAG>>=4
addx.w    d0,&dAG        ; round dAG
move.w    &dAG,(&addr2)  ; *(short *)&addr2=dAG

endm

-----
macro
BwdEnd2    &addr2,&dAG,&dAH,&DBH

move.w    (&addr2),d0    ; v=*(short *)&addr2
move.w    d0,d1          ; vs=v
add.w     d1,d1          ; vs<<=1 (vs=2v)
add.w     d1,d0          ; v+=vs (v=3v)
lsl.w     #2,d1          ; vs<<=2 (vs=8v)
move.w    d1,&DBH        ; DBH=vs
add.w     d1,d0          ; v+=vs (v=11v)
add.w     d0,&dAH        ; dAH+=v
add.w     d1,d0          ; v+=vs (v=19v)
add.w     d0,&dAG        ; dAG+=v

endm

-----
macro
BwdEnd1    &addr3,&addr2,&addr1,&dAG,&dAH,&DBH

```

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Engineering:Kl:csCode:CompPict:ConvolveSH3.a

```

move.w    (&addr3),d0      ; v=(short *)addr3
move.w    d0,d1            ; vs=v
add.w     d1,d1            ; vs<=<=1 (vs=2v)
add.w     d1,d0            ; v+=vs (v=3v)
add.w     d0,&dAH          ; dAH+=v
add.w     d0,&dAG          ; dAG+=v
add.w     d1,&dAG          ; dAG+=vs
add.w     d1,&dBH          ; dBH+=vs
lsl.l     #4,d1            ; vs<=<=4 (v=32v)
sub.w     d1,&dBH          ; dBH-=vs
clr.w     d0               ; d0=0
asr.w     #4,&dAH          ; dAH>>=4
addx.w    d0,&dAH          ; round dAH
move.w    &dAH,(&addr1)    ; *(short *)addr1=dAH
asr.w     #4,&dAG          ; dAG>>=4
addx.w    d0,&dAG          ; round dAG
move.w    &dAG,(&addr2)    ; *(short *)addr2=dAG
asr.w     #3,&dBH          ; dBH>>=3
addx.w    d0,&dBH          ; round dBH
move.w    &dBH,(&addr3)    ; *(short *)addr3=dBH

endm

-----
macro
Bwd      &base,&end,&inc

movea.l  &base,a0          ; addr0=base
move.l   &inc,d0           ; d0=inc
asr.l    #2,d0             ; d0=inc>>2
movea.l  a0,a3             ; addr3=addr0
suba.l   d0,a3             ; addr3-=(inc>>2)
movea.l  a3,a2             ; addr2=addr3
suba.l   d0,a2             ; addr2-=(inc>>2)
movea.l  a2,a1             ; addr1=addr2
suba.l   d0,a1             ; addr1-=(inc>>2)
BwdStart0 a0,d4,d5,d7      ; BwdStart0(addr0,dAG,dAH,dBH)
adda.l   &inc,a1           ; addr1+=inc
BwdStart1 a1,a0,d4,d5,d7   ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l   &inc,a2           ; addr2+=inc
@do
BwdEven  a2,d4,d5,d6,d7    ; BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l   &inc,a3           ; addr3+=inc
BwdOdd   a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l   &inc,a0           ; addr0+=inc
BwdEven  a0,d6,d7,d4,d5    ; BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l   &inc,a1           ; addr1+=inc
BwdOdd   a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l   &inc,a2           ; addr2+=inc
cmpa.l   a2,&end           ; addr2<end
bgt      @do              ; while
BwdEnd2  a2,d4,d5,d7       ; BwdEnd2(addr2,dAG,dAH,dBH)
adda.l   &inc,a3           ; addr3+=inc
BwdEnd3  a3,a2,a1,d4,d5,d7 ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB

endm

-----
FastBackward  FUNC  EXPORT
link          a6,#0          ; no local variables
movem.l       d4-d7/a3-a5,-(a7) ; store registers
move.l        $000C(a6),d3    ; inc=inc1
moves.l       $0008(a6),a5    ; base=data

```


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Engineering:KlicsCode:CompPict:ConvolveSH3.a

```

@do      movea.l    a5,a4                ; end=base
         adda.l     $0010(a6),a4         ; end+=end1
         bwd        a5,a4,d1            ; Bwd(base,end,inc)
         adda.l     $0014(a6),a5         ; base+=inc2
         cmpa.l     $0018(a6),a5        ; end2>base
         blt.w      @do                 ; for

         movem.l    (a7)+,d4-d7/a3-a5    ; restore registers
         unlk       a6                  ; remove locals
         rts                          ; return

```

ENDFUNC

END

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Engineering:KlicsCode:CompPict:Colour.c

```

.....
* Copyright 1993 KLICS Limited
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* Written by: Adrian Lewis
...../
/*
* Test versions of colour space conversions in C
*/

#include <Memory.h>
#include <QuickDraw.h>

#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr=(type)NewPtr(size))) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr=(type)NewPtr(size))) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef union {
    long    pixel;
    char    rgb[4];
} Pixel;

/* Special YUV space version */
#define rgb_yuv(pixmap,Yc) \
    pixel.pixel=0x808080^pixmap++; \
    r=(short)pixel.rgb[1]; \
    g=(short)pixel.rgb[2]; g+=g; \
    b=(short)pixel.rgb[3]; \
    Y=(b<<3)-b; \
    g+=r; \
    Y+=g+g+g; \
    Y>>=4; \
    Y+=g; \
    *Yc++=Y; \
    Y>>=2; \
    U+=b-Y; \
    V+=r-Y;

#define limit(Y,low,high) \
    Y<(low<<2)?low<<2:Y>(high<<2)?high<<2:Y

/* Standard YUV space version - Bt294 CR07(0) mode limiting */
#define rgb_yuv32(pixmap,Yc) \
    pixel.pixel=0x808080^pixmap++; \
    r=(long)pixel.rgb[1]; \
    g=(long)pixel.rgb[2]; \
    b=(long)pixel.rgb[3]; \
    Y= (306*r + 601*g + 117*b)>>8; \
    *Yc++ = limit(Y,16-128,235-128); \
    U= (512*r - 429*g - 83*b)>>8; \
    V= (-173*r - 339*g + 512*b)>>8;

void    RGB2YUV32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid

```

Engineering:KlicsCode:CompPict:Colour.c

```

long    *pixmap2=pixmap+cols, *row, *end=pixmap+area;
short    *Yc2=Yc+width;

while(pixmap<end) {
    row=pixmap+width;
    while(pixmap<row) {
        Pixel    pixel;
        long      r,g,b,Y,U=0,V=0;

        rgb_yuv32(pixmap,Yc);
        rgb_yuv32(pixmap,Yc);
        rgb_yuv32(pixmap2,Yc2);
        rgb_yuv32(pixmap2,Yc2);
        U>>=2;
        V>>=2;
        *Uc++=limit(U,16-128,240-128);
        *Vc++=limit(V,16-128,240-128);
    }
    pixmap+=cols+cols-width;
    pixmap2+=cols+cols-width;
    Yc+=width;
    Yc2+=width;
}

typedef struct {
    short    ry, rv, by, bu;
} RGB_Tab;

OSErr RGBTable(long **tab)
{
    RGB_Tab *table;
    int      i;
    THz      saveZone;

    NewPointer(table,RGB_Tab*,256*sizeof(RGB_Tab));
    *tab=(long *)table;
    for(i=0;i<128;i++) {
        table[i].ry=306*i>>8;
        table[i].rv=173*i>>8;
        table[i].by=117*i>>8;
        table[i].bu=83*i>>8;
    }
    for(i=128;i<256;i++) {
        table[i].ry=306*(i-256)>>8;
        table[i].rv=173*(i-256)>>8;
        table[i].by=117*(i-256)>>8;
        table[i].bu=83*(i-256)>>8;
    }
    return(noErr);
}

typedef struct {
    short    ru, gu, bv, gv;
} UV32_Tab;

UV32_Tab *UV32_Table()
{
    UV32_Tab *table;
    int      i;

    table=(UV32_Tab *)NewPtr(256*sizeof(UV32_Tab));

```

Engineering:KlacsCode:CompPict:Colour.c

```

    for(i=0;i<128;i++) {
        table[i].ru=128+(1436*i>>10);
        table[i].gu=128+(-731*i>>10);
        table[i].bv=128+(1815*i>>10);
        table[i].gv=-352*i>>10;
    }
    for(i=128;i<256;i++) {
        table[i].ru=128+(1436*(i-256)>>10);
        table[i].gu=128+(-731*(i-256)>>10);
        table[i].bv=128+(1815*(i-256)>>10);
        table[i].gv=-352*(i-256)>>10;
    }
    return(table);
}

typedef struct {
    long    u, v;
} UV32Tab;

OSErr  UV32Table(long **tab)
{
    long    *ytab;
    UV32Tab *uvtab;
    int     i;
    THz     saveZone;

    NewPointer(*tab,long*,512*sizeof(long)+512*sizeof(UV32Tab));
    ytab=*tab;
    uvtab=(UV32Tab*)&ytab[512];
    for(i=-256;i<256;i++) {
        long    yyy, sp;

        sp=0x000000fe&(i<-128?0:i>127?255:i+128);
        yyy=sp; yyy<=8;
        yyy|=sp; yyy<=8;
        yyy|=sp;
        ytab[0x000001ff&i]=yyy;
    }
    for(i=-256;i<256;i++) {
        long    ru,gu,bv,gv;

        ru=0xffffffff&(1436*i>>10);
        gu=0x000001fe&(-731*i>>10);
        bv=0x000001fe&(1815*i>>10);
        gv=0x000001fe&(-352*i>>10);

        uvtab[0x000001ff&i].u=((ru<<8)|gu)<<8;
        uvtab[0x000001ff&i].v=(gv<<8)|bv;
    }
    return(noErr);
}

typedef struct {
    short    u, v;
} UV16Tab;

OSErr  UV16Table(long **tab)
{
    short    *ytab;
    UV16Tab *uvtab;
    int     i;
    THz     saveZone;

```

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Engineering:KilcsCode:CompPict:Colour.c

```

NewPointer(*tab, long*, 512*sizeof(short)-512*sizeof(UV16Tab));
ytab=(short **)tab;
uvtab=(UV16Tab*)&ytab[512];
for(i=-256;i<256;i++) (
    long    yyy, sp;

    sp=0x0000001e&((i<-128?0:i>127?255:i-128)>>3);
    yyy=sp; yyy<=5;
    yyy|=sp; yyy<=5;
    yyy|=sp;
    ytab[0x000001ff&i]=yyy;

    for(i=-256;i<256;i++) (
        long    ru,gu,bv,gv;

        ru=0xffffffff&(1436*i>>13);
        gu=0x0000003e&(-731*i>>13);
        bv=0x0000003e&(1815*i>>13);
        gv=0x0000003e&(-352*i>>13);

        uvtab[0x000001ff&i].u=((ru<<5)|gu)<<5;
        uvtab[0x000001ff&i].v=(gv<<5)|bv;
    )
    return(noErr);
}

#define over(val) \
    ((0xFF00&(val)) == 0)?(char)val:val<0?0:255

/* Standard YUV space version */
#define yuv_rgb32(pixmap,Yc) \
    Y=(*Yc++)>>2; \
    pixel.rgb[1]=over(Y+r); \
    pixel.rgb[2]=over(Y+g); \
    pixel.rgb[3]=over(Y+b); \
    *pixmap++=pixel.pixel;

void    YUV2RGB32(long *pixmap, short *Yc, short *Uc, short *Vc, int area, int wid
(
    long    *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short    *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel    pixel;
            long    r,g,b,Y,U,V;

            U=(*Uc++)>>2;
            V=(*Vc++)>>2;
            r=128+(1436*U>>10);
            g=128+(-731*U - 352*V>>10);
            b=128+(1815*V>>10);

            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap,Yc);
            yuv_rgb32(pixmap2,Yc2);
            yuv_rgb32(pixmap2,Yc2);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
    }

```

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Engineering:KlicsCode:CompPict:Colour.c

```

    Yc2+=width;
)
)

#define rgb32_yuv(pixmap,Yc) \
    pixel.pixel=0x808080**pixmap++; \
    r=pixel.rgb[1]; \
    g=pixel.rgb[2]; \
    b=pixel.rgb[3]; \
    Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + table[0xFF&b \
    *Yc++ = limit(Y,16-128,235-128); \
    U+= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu; \
    V+= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

void RGB32YUV( RGB_Tab *table, long *pixmap, short *Yc, short *Uc, short *Vc, int
(
    long *pixmap2=pixmap+cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        row=pixmap+width;
        while(pixmap<row) {
            Pixel pixel;
            long r,g,b,Y,U=0,V=0;

            /*
                rgb32_yuv(pixmap,Yc);*/
            pixel.pixel=0x808080**pixmap++;
            r=pixel.rgb[1];
            g=pixel.rgb[2];
            b=pixel.rgb[3];
            Y= (table[0xFF&r].ry + (g<<2)-table[0xFF&g].ry-table[0xFF&g].by + tabl
            *Yc++ = limit(Y,16-128,235-128);
            U+= (r<<1) -g -table[0xFF&g].rv - table[0xFF&b].bu;
            V+= (b<<1) -g -table[0xFF&r].rv - table[0xFF&g].bu;

            rgb32_yuv(pixmap,Yc);
            rgb32_yuv(pixmap2,Yc2);
            rgb32_yuv(pixmap2,Yc2);
            U>>=2;
            V>>=2;
            *Uc++=limit(U,16-128,240-128);
            *Vc++=limit(V,16-128,240-128);
        }
        pixmap+=cols+cols-width;
        pixmap2+=cols+cols-width;
        Yc+=width;
        Yc2+=width;
    }
)

#define yuv_rgb32x2(pixmap,Y) \
    pixel.rgb[1]=over(Y+r); \
    pixel.rgb[2]=over(Y+g); \
    pixel.rgb[3]=over(Y+b); \
    pixmap[cols]=pixel.pixel; \
    *pixmap++=pixel.pixel;

void YUV2RGB32x2(UV32_Tab *table, long *pixmap, short *Yc, short *Uc, short *Vc,
(
    long *pixmap2=pixmap+2*cols, *row, *end=pixmap+area;
    short *Yc2=Yc+width;

```

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Engineering:Kl:csCode:CompPict:Colour.c

```

while(pixmap<end) {
    long    Yold=*Yc>>2, Yold2=*Yc2>>2;

    row=pixmap+width*2;
    while(pixmap<row) {
        Pixel pixel;
        long    r,g,b,Y,U,V;

        U=0x00FF&((*Uc++)>>2);
        V=0x00FF&((*Vc++)>>2);
        r=table[U].ru;
        g=table[U].gu+table[V].gv;
        b=table[V].bv;

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc++)>>2;
        Yold=(Y+Yold)>>1;
        yuv_rgb32x2(pixmap,Yold);

        Yold=Y;
        yuv_rgb32x2(pixmap,Yold);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);

        Y=(*Yc2++)>>2;
        Yold2=(Y+Yold2)>>1;
        yuv_rgb32x2(pixmap2,Yold2);

        Yold2=Y;
        yuv_rgb32x2(pixmap2,Yold2);
    }
    pixmap+=4*cols-2*width;
    pixmap2+=4*cols-2*width;
    Yc+=width;
    Yc2+=width;
}

#define yuv_rgb8(pixel,Yc,index,dith) \
    Y=*Yc++; \
    Y<=3; \
    Y&= 0x3F00; \
    Y|= U; \
    pixel.rgb[index]=table[Y].rgb[dith];

void    YUV2RGB8(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int a
{
    long    *pixmap2=pixmap+cols/1, *row, *end=pixmap+area/4;
    short    *Yc2=Yc+width;

    while(pixmap<end) {

```

Engineering:KlicsCode:CompPict:Colour.c

```

row=pixmap+width/4;
while(pixmap<row) {
    Pixel pixel, pixel2;
    long Y,U,V;

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,0,3);
    yuv_rgb8(pixel,Yc,1,0);
    yuv_rgb8(pixel2,Yc2,0,1);
    yuv_rgb8(pixel2,Yc2,1,2);

    U=*Uc++;
    V=*Vc++;
    U>>=2;
    V>>=6;
    U= (U&0xF0) | (V&0x0F);

    yuv_rgb8(pixel,Yc,2,3);
    yuv_rgb8(pixel,Yc,3,0);
    yuv_rgb8(pixel2,Yc2,2,1);
    yuv_rgb8(pixel2,Yc2,3,2);

    *pixmap++=pixel.pixel;
    *pixmap2++=pixel2.pixel;
}
pixmap+=(cols+cols-width)/4;
pixmap2+=(cols+cols-width)/4;
Yc+=width;
Yc2+=width;
}

#define yuv_rgb8x2(pixel,pixel2,Y,index,dith,dith2) \
    Y&= 0x3F00; \
    Y|= 0; \
    pixel.rgb[index]=table[Y].rgb[dith]; \
    pixel2.rgb[index]=table[Y].rgb[dith2];

void YUV2RGB8x2(Pixel *table,long *pixmap, short *Yc, short *Uc, short *Vc, int
{
    long *pixmap2=pixmap+cols/2, *row, *end=pixmap+area/4;
    short *Yc2=Yc+width;

    while(pixmap<end) {
        long Yold=*Yc<<3, Yold2=*Yc2<<3;

        row=pixmap+width/2;
        while(pixmap<row) {
            Pixel pixel, pixel2, pixel3, pixel4;
            long Y,U,V;

            U=*Uc++;
            V=*Vc++;
            U>>=2;
            V>>=6;
            U= (U&0x00F0) | (V&0x000F);

            Y=(*Yc++)<<3;

```


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Engineering:KlicsCode:CompPict:Colour.c

```

long r,g,b,Y,U,V;

U=0x00FF&((*Uc++)>>2);
V=0x00FF&((*Vc++)>>2);
r=table[U].ru;
g=table[U].gu+table[V].gv;
b=table[V].bv;

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
rgb_col.red=(Yold+r<<8);
rgb_col.green=(Yold+g<<8);
rgb_col.blue=(Yold+b<<8);
pixel.rgb[0]=Color2Index(&rgb_col);

Yold=Y;
yuv_rgbTEST(pixel,1,Yold);

Y=(*Yc++)>>2;
Yold=(Y+Yold)>>1;
yuv_rgbTEST(pixel,2,Yold);

Yold=Y;
yuv_rgbTEST(pixel,3,Yold);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,0,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,1,Yold2);

Y=(*Yc2++)>>2;
Yold2=(Y+Yold2)>>1;
yuv_rgbTEST(pixel2,2,Yold2);

Yold2=Y;
yuv_rgbTEST(pixel2,3,Yold2);

pixmap[cols/4]=pixel.pixel;
*pixmap++=pixel.pixel;

pixmap2[cols/4]=pixel2.pixel;
*pixmap2++=pixel2.pixel;
)
pixmap+=(cols+cols-width)/2;
pixmap2+=(cols+cols-width)/2;
Yc+=width;
Yc2+=width;

```

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Engineering:KlicsCode:CompPict:Colour.a

```

-----
*
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
-----
*
*   68030 Colour space conversions
*
-----
machine mc68030
seg      'klics'
include  'Traps.a'
-----
macro
DPY12x2      &ARGB, &row, &o0, &ol, &n0, &n1

    add.l      &n0, &o0
    lsr.l      #1, &o0                ; interpolate first pixel
    add.l      &n1, &ol
    lsr.l      #1, &ol                ; interpolate first pixel

    move.l     &o0, (&ARGB)
    add.l     &row, &ARGB
    move.l     &o0, (&ARGB)
    add.l     &row, &ARGB
    move.l     &ol, (&ARGB)
    add.l     &row, &ARGB
    move.l     &ol, (&ARGB)+

    move.l     &n1, (&ARGB)
    sub.l     &row, &ARGB
    move.l     &n1, (&ARGB)
    sub.l     &row, &ARGB
    move.l     &n0, (&ARGB)
    sub.l     &row, &ARGB
    move.l     &n0, (&ARGB)+

endm

-----
macro
DPY32      &ARGB, &row, &o0, &ol, &n0, &n1

    move.l     &o0, (&ARGB)
    add.l     &row, &ARGB
    move.l     &ol, (&ARGB)+

    move.l     &n1, (&ARGB)
    sub.l     &row, &ARGB
    move.l     &n0, (&ARGB)+

endm

-----
macro
UV2RGB32      &AU, &AV, &TAB

    add.l      #2048, &TAB                ; move to uvtab

    move.w     &AU, d1                    ; Load U
    lsr.w      #2, d1
    and.w      #501FF, d1

```

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Engineering:KlicsCode:CompPict:Colour.a

```

move.l    (&TAB,d1.w*8),d0      ; UV now rg (u)
move.w    &AV,d1                ; Load V
lsr.w     #2,d1
and.w     #$01FF,d1
add.l     4(&TAB,d1.w*8),d0      ; UV now rgb

move.l    d0,d1                ; 3 copies
move.l    d0,d2
move.l    d0,d3

sub.l     #2048,&TAB            ; restore ytab

endm

```

```

macro
GETY32    &AY, &TAB, &RGB0, &RGB1

move.l    &AY,d4                ; Y
lsr.w     #2,d4
and.w     #$01FF,d4
add.l     (&TAB,d4.w*4),&RGB1    ; RGB1+=YYY

swap      d4
lsr.w     #2,d4
and.w     #$01FF,d4
add.l     (&TAB,d4.w*4),&RGB0    ; RGB0+=YYY

endm

```

```

macro
OVER32    &RGB

move.l    &RGB,d4                ; copy pixel
andi.l    #$01010100,d4          ; was it this rgb
beq.s     @nx_rgb                ; if not then quit
btst      #24,d4                 ; R overflow?
beq.s     @bit16                 ; if not then continue
btst      #23,&RGB                ; test sign
beq.s     @pos23                 ; if positive
andi.l    #$0000ffff,&RGB        ; underflow sets R to 0
bra.s     @bit16                 ; do next bit
@pos23    ori.l    #$00ff0000,&RGB ; overflow sets R to 255
@bit16    btst     #16,d4          ; G overflow?
beq.s     @bit8                 ; if not then continue
btst      #15,&RGB                ; test sign
beq.s     @pos16                 ; if positive
andi.w    #$00ff,&RGB            ; underflow sets G to 0
bra.s     @bit8                 ; do next bit
@pos16    ori.w    #$fff0,&RGB     ; overflow sets G to 255
@bit8     btst     #8,d4           ; B overflow?
beq.s     @end                  ; if not then continue
btst      #7,&RGB                ; test sign
seq       &RGB                   ; under/over flow
@end      andi.l    #$00fefefe,&RGB ; mask RGB ok
@nx_rgb

endm

```

```

macro
HASHOUT32 &AH, &D0, &D1, &D2, &D3

move.l    &D0,d4

```

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Engineering:KlicsCode:CompPict:Colour.a

```

add.l    >    &D1,d4
add.l    &D2,d4
add.l    &D3,d4
andi.l   &S03e3e3e0,d4
move.l   d4,&AH

```

```

endm

```

```

macro
HASHCMP32    &AH, &D0, &D1, &D2, &D3

```

```

move.l    &D0,d4
add.l     &D1,d4
add.l     &D2,d4
add.l     &D3,d4
andi.l    &S03e3e3e0,d4
cmp.l     &AH,d4

```

```

endm

```

```

-----
OUT32X2 FUNC      EXPORT

```

```

PS      RECORD      8
table   DS.L         1
pixmap  DS.L         1
Y       DS.L         1
U       DS.L         1
V       DS.L         1
width   DS.L         1
height  DS.L         1
rowByte DS.L         1
pixmap2 DS.L         1
        ENDR

```

```

LS      RECORD      0,DECR
Yl      DS.L         1      ; sizeof(short)*Yrow      = 2*width
U_ex    DS.L         1      ; x end address          = U+U_ix
U_ey    DS.L         1      ; y end address          = U+width*height>>
U_ix    DS.L         1      ; sizeof(short)*Uvrow    = width
Y_y     DS.L         1      ; sizeof(short)*Yrow     = 2*width
P_y     DS.L         1      ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
LSize   EQU          *
        ENDR

```

```

a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

```

```

link      a6,*LS.LSize      ; inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7) ; store registers

```

```

move      SR,d0

```

```

move.l    PS.Y(a6),a0      ; Y=Yc
move.l    PS.U(a6),a1      ; U=Uc
move.l    PS.V(a6),a2      ; V=Vc
move.l    PS.pixmap(a6),a3 ; pm=pixmap
move.l    PS.table(a6),a4   ; tab=table
move.l    PS.pixmap2(a6),a5 ; pm2=pixmap2

```

```

move.l    PS.width(a6),d0   ; LOAD width
move.l    d0,LS.U_ix(a6)    ; SAVE U_ix
move.l    PS.height(a6),d1  ; LOAD height
mulu.w    d0,d1             ; width*height

```

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Engineering:KlicsCode:CompPict:Colou:..a

```

lsr.l      #1,d1      ; width*height/2
add.l      a1,d1      ; U*width*height/2
move.l     d1,LS_U_ey(a6) ; SAVE U_ey
add.l      d0,d0      ; width*2
move.l     d0,LS_Y1(a6) ; SAVE Y1
move.l     d0,LS_Y_y(a6) ; SAVE Y_y
lsl.l      #2,d0      ; width*8
move.l     PS_rowByte(a6),d1 ; LOAD rowBytes
lsl.l      #2,d1      ; rowBytes*4
sub.l      d0,d1      ; rowBytes*4-width*8
move.l     d1,LS_P_y(a6) ; SAVE P_y

move.l     PS_rowByte(a6),d5 ; load rowBytes
clr.l      d6         ; clear old2
clr.l      d7         ; clear old1

@do_y      move.l     LS_U_ix(a6),d0 ; LOAD U_ixB
add.l      a1,d0      ; P+U_ixB
move.l     d0,LS_U_ex(a6) ; SAVE U_exB

@do_x      UV2RGB32    (a1)+,(a2)+,a4 ; uv2rgb(*U++,*V++)

move.l     LS_Y1(a6),d4 ; load Yrow
GETY32     (a0,d4,1),a4,d2,d3 ; add Yb to RGB values
GETY32     (a0)+,a4,d0,d1 ; add Ya to RGB values

move.l     d0,d4
or.l       d1,d4
or.l       d2,d4
or.l       d3,d4
andi.l     #S01010100,d4
bne.s      @over      ; if overflow

@ok        HASHOUT32   (a5)+,d0,d1,d2,d3

DPY32x2    a3,d5,d6,d7,d0,d2
DPY32x2    a3,d5,d0,d2,d1,d3

move.l     d1,d6
move.l     d3,d7      ; copy olds

cmpa.l     LS_U_ex(a6),a1
blt.w      @do_x

add.l      LS_Y_y(a6),a0
add.l      LS_P_y(a6),a3

cmpa.l     LS_U_ey(a6),a1
blt.w      @do_y

movem.l    (a7)+,d4-d7/a3-a5 ; restore registers
unlk       a6           ; remove locals
rts        ; return

@over      OVER32      d0
OVER32     d1
OVER32     d2
OVER32     d3
bra        @ok

```

ENDFUNC

OUT32X2D	FUNC	EXPORT
----------	------	--------

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Engineering:KlicsCode:CompPict:Colour.a

```

GETY32      (a0)+,a4,d0,d1      ; add Ya to RGB values
move.l      d0,d4
or.l        d1,d4
or.l        d2,d4
or.l        d3,d4
andi.l      #$01010100,d4
bne.w       @over              ; if overflow

@ok          HASHCMP32 (a5)+,d0,d1,d2,d3
bne.s       @diff

add.l       #16,a3              ; add four pixels

@cont        move.l      d1,d6      ; copy olds
move.l      d3,d7

cmpa.l      LS.U_ex(a6),a1
blt.w       @do_x

add.l       LS.Y_y(a6),a0
add.l       LS.P_y(a6),a3

cmpa.l      LS.U_ey(a6),a1
blt.w       @do_y

movem.l     (a7)+,d4-d7/a3-a5      ; restore registers
unlk        a6                    ; remove locals
rts          ; return

@diff        move.l      d4,-4(a5)
DPY32x2     a3,d5,d6,d7,d0,d2
DPY32x2     a3,d5,d0,d2,d1,d3
bra.s       @cont

@over        OVER32      d0
OVER32      d1
OVER32      d2
OVER32      d3
bra         @ok

```

ENDFUNC

```

-----
OUT32  FUNC      EXPORT
PS      RECORD      8
cable   DS.L        1
pixmap  DS.L        1
Y        DS.L        1
U        DS.L        1
V        DS.L        1
width   DS.L        1
height  DS.L        1
rowByte  DS.L        1
pixmap2 DS.L        1
*        ENDR

LS      RECORD      0,DECR
Y1      DS.L        1          ; sizeof(short)*Yrow          = 2*width
U_ex    DS.L        1          ; x end address              = U+U_ix
U_ey    DS.L        1          ; y end address              = U+width*height>>
U_ix    DS.L        1          ; sizeof(short)*U/row       = width
Y_y     DS.L        1          ; sizeof(short)*Yrow        = 2*width
P_y     DS.L        1          ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize   EQU         .

```


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Engineering:KlacsCode:CompPict:Colour.a

```

ENDR
.
.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - cld0, d7

link      a6, #LS.LSize      ; inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5, -(a7) ; store registers

move.l    PS.Y(a6), a0      ; Y=Yc
move.l    PS.U(a6), a1      ; U=Uc
move.l    PS.V(a6), a2      ; V=Vc
move.l    PS.pixmap(a6), a3 ; pm=pixmap
move.l    PS.table(a6), a4   ; tab=table
move.l    PS.pixmap2(a6), a5 ; pm2=pixmap2

move.l    PS.width(a6), d0   ; LOAD width
move.l    d0, LS.U_ix(a6)    ; SAVE U_ix
move.l    PS.height(a6), d1  ; LOAD height
mulu.w    d0, d1             ; width*height
lsr.l     #1, d1             ; width*height/2
add.l     a1, d1             ; U*width*height/2
move.l    d1, LS.U_ey(a6)    ; SAVE U_ey
add.l     d0, d0             ; width*2
move.l    d0, LS.Y1(a6)      ; SAVE Y1
move.l    d0, LS.Y_y(a6)     ; SAVE Y_y
add.l     d0, d0             ; width*4
move.l    PS.rowByte(a6), d1 ; LOAD rowBytes
add.l     d1, d1             ; rowBytes*2
sub.l     d0, d1             ; rowBytes*2-width*4
move.l    d1, LS.P_y(a6)     ; SAVE P_y

move.l    PS.rowByte(a6), d5 ; load rowBytes
move.l    LS.Y1(a6), d6      ; load Yrow

@do_y     move.l    LS.U_ix(a6), d7 ; LOAD U_ixB
add.l     a1, d7            ; P+U_ixB

@do_x     UV2RGB32     (a1)+, (a2)+, a4 ; uv2rgb(*U++, *V++)

GETY32    (a0, d6.1), a4, d2, d3 ; add Yb to RGB values
GETY32    (a0)+, a4, d0, d1 ; add Ya to RGB values

move.l    d0, d4
or.l      d1, d4
or.l      d2, d4
or.l      d3, d4
andi.l    #01010100, d4
bne.s     @over ; if overflow

@ok       HASHOUT32    (a5)+, d0, d1, d2, d3

DPY32     a3, d5, d0, d2, d1, d3

cmpa.l    d7, a1
blt.w     @do_x

add.l     LS.Y_y(a6), a0
add.l     LS.P_y(a6), a3

cmpa.l    LS.U_ey(a6), a1
blt.w     @do_y

movem.l    (a7)+, d4-d7/a3-a5 ; restore registers

```

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Engineering:KlidsCode:CompPict:Colour.a

```

      unlink      = a6
      rts          ; remove locals
@over OVER32      d0          ; return
      OVER32      d1
      OVER32      d2
      OVER32      d3
      bra         3ok

      ENDFUNC
-----
OUT32D  FUNC      EXPORT
PS      RECORD    8
table   DS.L      1
pixmap  DS.L      1
Y       DS.L      1
U       DS.L      1
V       DS.L      1
width   DS.L      1
height  DS.L      1
rowByte DS.L      1
pixmap2 DS.L      1
      ENDR

LS      RECORD    0,DECR
Y1      DS.L      1
U_ex    DS.L      1      ; sizeof(short)*Yrow      = 2*width
U_ey    DS.L      1      ; x end address          = U+U_ix
U_ix    DS.L      1      ; y end address          = U+width*height>>
Y_y     DS.L      1      ; sizeof(short)*Uvrow    = width
P_y     DS.L      1      ; sizeof(short)*Yrow     = 2*width
LSize   EQU       *      ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
      ENDR

      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - Yrow, d7

      link      a6,#LS.LSize      ; inc. width, fend and rowend are loca
      movem.l   d4-d7/a3-a5,-(a7) ; store registers

      move.l    PS.Y(a6),a0        ; Y=Yc
      move.l    PS.U(a6),a1        ; U=Uc
      move.l    PS.V(a6),a2        ; V=Vc
      move.l    PS.pixmap(a6),a3   ; pm=pixmap
      move.l    PS.table(a6),a4    ; tab=table
      move.l    PS.pixmap2(a6),a5  ; pm2=pixmap2

      move.l    PS.width(a6),d0     ; LOAD width
      move.l    d0,LS.U_ix(a6)     ; SAVE U_ix
      move.l    PS.height(a6),d1   ; LOAD height
      mulu.w    d0,d1              ; width*height
      lsr.l     #1,d1              ; width*height/2
      add.l     a1,d1              ; U+width*height/2
      move.l    d1,LS.U_ey(a6)     ; SAVE U_ey
      add.l     d0,d0              ; width*2
      move.l    d0,LS.Y1(a6)       ; SAVE Y1
      move.l    d0,LS.Y_y(a6)      ; SAVE Y_y
      add.l     d0,d0              ; width*4
      move.l    PS.rowByte(a6),d1  ; LOAD rowBytes
      add.l     d1,d1              ; rowBytes*2
      sub.l     d0,d1              ; rowBytes*2-width*4
      move.l    d1,LS.P_y(a6)      ; SAVE P_y

```

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Engineering:KlicsCode:CompPict:Colour.a

```

        move.l    => PS.rowByte(a6),d5      ; load rowBytes
        move.l    LS.Y1(a6),d6              ; load Yrow
@do_y    move.l    LS.U_ix(a6),d7            ; LOAD U_ixB
        add.l     a1,d7                      ; P+U_ixB
@do_x    UV2RGB32    (a1)+,(a2)+,a4          ; uv2rgb(*U++,*V++)
        move.l    LS.Y1(a6),d4              ; load Yrow
        GETY32     (a0,d6.1),a4,d2,d3        ; add Yb to RGB values
        GETY32     (a0)+,a4,d0,d1           ; add Ya to RGB values

        move.l    d0,d4
        or.l      d1,d4
        or.l      d2,d4
        or.l      d3,d4
        andi.l    $01010100,d4
        bne.s     @over                      ; if overflow
@ok       HASHCMP32    (a5)+,d0,d1,d2,d3
        bne.s     @diff
        addq      #8,a3                      ; add four pixels
@cont     cmpa.l     d7,a1
        blt.w     @do_x
        add.l     LS.Y_y(a6),a0
        add.l     LS.P_y(a6),a3
        cmpa.l     LS.U_ey(a6),a1
        blt.w     @do_y
        movem.l    (a7)+,d4-d7/a3-a5        ; restore registers
        unlk      a6                        ; remove locals
        rts                          ; return
@diff     move.l    d4,-4(a5)
        DPY32      a3,d5,d0,d2,d1,d3
        bra.s     @cont
@over     OVER32    d0
        OVER32     d1
        OVER32     d2
        OVER32     d3
        bra       @ok

        ENDFUNC
-----
        macro
        UVOV      &VAL, &OV

        move.w     &VAL,&OV
        add.w      #0200,&OV
        and.w      #0FC00,&OV
        beq.s      @ok
        tst.w      &OV
        bge.s      @pos
        move.w     #01FF,&VAL
        bra.s      @ok
@pos       move.w     #0FE00,&VAL
@ok
        endm

```

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Engineering:KlicsCode:CompPict:Colour.a

```

UVLIMIT FUNC      EXPORT
* fix d0, d4, spare d1, d2
  UVOV            d0, d1
  swap            d0
  UVOV            d0, d1
  swap            d0
  UVOV            d4, d1
  swap            d4
  UVOV            d4, d1
  swap            d4
  rts

ENDFUNC

macro
UVOVER            &U, &V

  move.l          #$02000200, d1
  move.l          d1, d2
  add.l           &U, d1
  add.l           &V, d2
  or.l            d2, d1
  andi.l          #SFC00FC00, d1
  beq.s           @UVok
  bsr             UVLIMIT
@UVok

endm

macro
GETUV            &AU, &AV, &SP, &UV

  move.l          (&AU)+, &SP
  move.l          (&AV)+, &UV
  UVOVER          &SP, &UV
  lsr.l           #5, &UV
  andi.l          #03e003e0, &SP
  andi.l          #001F001F, &UV
  or.l            &SP, &UV
  swap            &UV
; UV==S00UV00UV

endm

macro
GETY            &AY, &IND, &UV, &R0, &R1

  move.l          &AY, &R1
  lsl.l           #5, &R1
  andi.l          #SFC00FC00, &R1
  or.w           &UV, &R1
  move.l          (&IND, &R1 .w*4), &R0
  swap           &R1
  or.w           &UV, &R1
  move.l          (&IND, &R1 .w*4), &R1
; (2+) Y=Y0Y1
; (4) Y=Y0XXY1XX
;
; (2) Y=Y1UV
; (2+) R0=0123 (Y1)
; (4) Y=Y0XX
; (2) Y=Y0UV
; (2+) R1=0123 (Y0)

endm

macro
UV8            &AU, &AV, &SP, &UV

  move.l          (&AU)+, &SP
  move.l          (&AV)+, &UV
  UVOVER          &SP, &UV

```

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Engineering:KlicsCode:CompPict:Colour.a

```

move.l    d0,LS.U_ix(a6)      ; SAVE U_ix
move.l    = PS.height(a6),d1  ; LOAD height
mulu.w    d0,d1               ; width*height
lsr.l     #1,d1               ; width*height/2
add.l     a1,d1               ; U*width*height/2
move.l    d1,LS.U_ey(a6)     ; SAVE U_ey
move.l    PS.rowByte(a6),d1   ; LOAD rowBytes
add.l     d1,d1               ; rowBytes*2
sub.l     d0,d1               ; rowBytes*2-width
move.l    d1,LS.P_y(a6)       ; SAVE P_y
add.l     d0,d0               ; width*2
move.l    d0,LS.Y1(a6)        ; SAVE Y1
move.l    d0,LS.Y_y(a6)       ; SAVE Y_y

move.l    PS.rowByte(a6),d5   ; load rowBytes
move.l    LS.Y1(a6),d6        ; load Yrow

@do_y     move.l    LS.U_ix(a6),d7 ; LOAD U_ixB
add.l     a1,d7               ; P+U_ixB

@do_x     GETUV              a1,a2,d0,d4

GETY      (a0,d6.w),a4,d4,d2,d3 ; d2=X0XX, d3=XX1X
GETY      (a0)+,a4,d4,d0,d1    ; d0=XX00, d1=1XX0

move.w    d3,d2               ; d2=X01X
lsr.l     #8,d2               ; d2=01XX
move.w    d0,d1               ; d1=1XX0
swap      d1                  ; d1=X01X
lsr.l     #8,d1               ; d1=01XX

swap      d4                   ; next UV

GETY      (a0,d6.l),a4,d4,d0,d3 ; d0=X2XX, d3=XX3X
move.w    d3,d0               ; d0=X23X
lsr.l     #8,d0               ; d0=XX23
move.w    d0,d2               ; d2=0123
GETY      (a0)+,a4,d4,d0,d3    ; d0=XX02, d3=3XX0
move.w    d0,d3               ; d3=3XX2
swap      d3                  ; d3=X23X
lsr.l     #8,d3               ; d3=XX23
move.w    d3,d1               ; d1=0123

move.l    d2,(a3,d5)
move.l    d1,(a3)+

cmpa.l    d7,a1
blt.w     @do_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS.U_ey(a6),a1
blt.w     @do_y

movem.l   (a7)+,d4-d7/a3-a5    ; restore registers
unlk     a6                    ; remove locals
rts      ; return

ENDFUNC
-----
macro
Y8x2      &AY,&IND,&UV,&old

```

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Engineering:KlicsCode:CompPict:Colour.a

```

move.l    &AY,d0                ; (2+) Y=Y0Y1
lsl.l     #3,d0                 ; (4) Y=Y0XXY1XX
swap      d0                    ; (4) Y=Y1XXY0XX
add.w     d0,&old                ; (2) old=old+Y0
lsr.w     #1,&old                ; (4) old=(old+Y0)/2
move.b    &UV,&old              ; (2) old=Y10UV
andi.w    #51FFF,&old           ; (4) old=0YUV(I0)
move.l    (&IND,&old.w*4),d1     ; (2+) d1=X1X3
move.w     d0,&old              ; (2) old=Y0
move.b     &UV,d0               ; (2) Y=Y0UV
andi.w    #53FFF,d0            ; (4) Y=0YUV(0)
move.l    (&IND,d0.w*4),d2     ; (2+) d2=0X2X
move.w     d1,d3               ; (2) exg.w d1,d2
move.w     d2,d1               ; (2) d1=X12X
move.w     d3,d2               ; (2) d2=0XX3
swap      d2                    ; (4) d2=X30X
lsl.l     #8,d1                ; (4) d1=12XX
lsl.l     #8,d2                ; (4) d2=30XX
swap      d0                    ; (4) Y=Y1XX
add.w     d0,&old              ; (2) old=old+Y1
lsr.w     #1,&old                ; (4) old=(old+Y1)/2
move.b     &UV,&old             ; (2) old=Y11UV
andi.w    #53FFF,&old          ; (4) old=0YUV(I1)
move.l    (&IND,&old.w*4),d3     ; (2+) d3=X1X3
move.w     d0,&old              ; (2) old=Y1
move.b     &UV,d0               ; (2) Y=Y0UV
andi.w    #53FFF,d0            ; (4) Y=0YUV(0)
move.l    (&IND,d0.w*4),d0     ; (2+) d0=0X2X
move.w     d0,d1               ; (2) exg.w d0,d3
move.w     d3,d0               ; (2) d0=0XX3
move.w     d1,d3               ; (2) d3=X12X
swap      d0                    ; (4) d0=X30X
lsr.l     #8,d0                ; (4) d0=XX30
lsr.l     #8,d3                ; (4) d3=X12X
move.w     d0,d2               ; (2) d2=3030 (YiY0YiY1) (1)
move.w     d3,d1               ; (2) d1=2121 (YiY0YiY1) (2)

```

endm

macro
Y8x2a

&AY,&IND,&UV

GETY

&AY,&IND,&UV,d1,d2

```

move.l    &AY,d2                ; (2+) Y=Y0Y1
lsl.l     #3,d2                 ; (4) Y=Y0XXY1XX
move.b     &UV,d2               ; (2) Y=Y1UV
andi.w    #53FFF,d2            ; (4) Y=0YUV(Y1)
move.l    (&IND,d2.w*4),d1     ; (2+) d1=0123 (Y1)
swap      d2                    ; (4) Y=Y0XX
move.b     &UV,d2               ; (2) Y=Y0UV
andi.w    #53FFF,d2            ; (4) Y=0YUV(Y0)
move.l    (&IND,d2.w*4),d2     ; (2+) d2=0123 (Y0)
move.w     d1,d0               ; (2) exg.w d2,d1
move.w     d2,d1               ; (2) d1=0123 (Y1Y0)
move.w     d0,d2               ; (2) d2=0123 (Y0Y1)
swap      d1                    ; (4) d1=2301 (Y0Y1)

```

endm

macro
Y8x2b

&AY,&IND,&UV

GETY

&AY,&IND,&UV,d1,d2

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Engineering:KlicsCode:CompPict:Colour.a

```

    .      move.l    = &AY,d2          : (2+) Y=Y0Y1
    .      lsl.l     #3,d2             : (4) Y=Y0XXY1XX
    .      move.b    &UV,d2           : (2) Y=Y1UV
    .      andi.w     #S3FFF,d2        : (4) Y=0YUV(Y1)
    .      move.l    (&IND,d2.w*4),d1  : (2+) d1=0123 (Y1)
    .      swap      d2                : (4) Y=Y0XX
    .      move.b    &UV,d2           : (2) Y=Y0UV
    .      andi.w     #S3FFF,d2        : (4) Y=0YUV(Y0)
    .      move.l    (&IND,d2.w*4),d2  : (2+) d2=0123 (Y0)
    .      ror.l     #8,d2             : (6) d2=3012 (Y0)
    .      ror.l     #8,d1             : (6) d1=3012 (Y1)
    .      move.w    d1,d0             : (2) exg.w d2,d1
    .      move.w    d2,d1             : (2) d1=3012 (Y1Y0)
    .      move.w    d0,d2             : (2) d2=3012 (Y0Y1)
    .      swap      d1                : (4) d1=1230 (Y0Y1)
    .      ror.w     #8,d1             : (6) d1=1203 (Y0Y1)
    .
    .      endm

```

OUT8x2 FUNC EXPORT

```

    .
    PS      RECORD      8
    table   DS.L         1
    pixmap  DS.L         1
    Y        DS.L         1
    U        DS.L         1
    V        DS.L         1
    width   DS.L         1
    height  DS.L         1
    rowByte DS.L         1
    pixmap2 DS.L         1
    .      ENDR

```

```

    LS      RECORD      0,DECR
    Y1      DS.L         1          ; sizeof(short)*Yrow      = 2*width
    U_ex    DS.L         1          ; x end address        = U+U_ix
    U_ey    DS.L         1          ; y end address        = U+width*height>>
    U_ix    DS.L         1          ; sizeof(short)*Uvrow  = width
    Y_y     DS.L         1          ; sizeof(short)*Yrow   = 2*width
    P_y     DS.L         1          ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
    LSize   EQU          *
    .      ENDR

```

```

    .
    .      a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
    .      d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d5 - old0, d7
    .
    link     a6,#LS.LSize
    movem.l  d4-d7/a3-a5,-(a7)      ; inc. width, fend and rowend are loca
    .                                     ; store registers
    .
    move.l   PS.Y(a6),a0             ; Y=YC
    move.l   PS.U(a6),a1             ; U=Uc
    move.l   PS.V(a6),a2             ; V=Vc
    move.l   PS.pixmap(a6),a3        ; pm=pixmap
    move.l   PS.table(a6),a4         ; tab=table
    adda.l   #S00020000,a4           ; tab+=32768 (longs)
    move.l   PS.pixmap2(a6),a5       ; pm2=pixmap2
    .
    move.l   PS.width(a6),d0         ; LOAD width
    move.l   d0,LS.U_ix(a6)          ; SAVE U_ix
    move.l   PS.height(a6),d1        ; LOAD height
    mulu.w   d0,d1                   ; width*height
    lsr.l    #1,d1                   ; width*height/2

```

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Engineering:KlicsCode:CompPict:Colour.a

```

add.l    a1,d1                ; U*width*height/2
move.l   d1,LS.U_ey(a6)       ; SAVE U_ey
add.l    d0,d0                ; width*2
move.l   d0,LS.Y1(a6)         ; SAVE Y1
move.l   d0,LS.Y_y(a6)        ; SAVE Y_y
move.l   PS.rowByte(a6),d1    ; LOAD rowBytes
add.l    d1,d1                ; rowBytes*2
add.l    d1,d1                ; rowBytes*4
sub.l    d0,d1                ; rowBytes*4-width*2
move.l   d1,LS.P_y(a6)        ; SAVE P_y

move.l   PS.rowByte(a6),d5    ; load rowBytes
clr.l    d6
clr.l    d7

@do_y    move.l   LS.U_ix(a6),d0    ; LOAD U_ixB
add.l    a1,d0                ; P+U_ixB
move.l   d0,LS.U_ex(a6)       ; SAVE U_exB

@do_x    GETUV    a1,a2,d0,d4    ; d4=00UV00UV (10)

Y8x2a    (a0),a4,d4;,d6        ; calc d2,d1 pixels
move.l   d2,(a3)
add.l    d5,a3
move.l   d1,(a3)
add.l    d5,a3

move.l   LS.Y1(a6),d0         ; load Yrow
Y8x2b    (a0,d0.w),a4,d4;,d7    ; calc d2,d1 pixels
move.l   d2,(a3)
add.l    d5,a3
move.l   d1,(a3)+

swap     d4                    ; next UV
addq.l   #4,a0                 ; next Ys

move.l   LS.Y1(a6),d0         ; load Yrow
Y8x2b    (a0,d0.w),a4,d4;,d7    ; calc d2,d1 pixels
move.l   d1,(a3)
sub.l    d5,a3
move.l   d2,(a3)
sub.l    d5,a3

Y8x2a    (a0)+,a4,d4;,d6
move.l   d1,(a3)
sub.l    d5,a3
move.l   d2,(a3)+

cmpa.l   LS.U_ex(a6),a1
blt.w    @do_x

add.l    LS.Y_y(a6),a0
add.l    LS.P_y(a6),a3

cmpa.l   LS.U_ey(a6),a1
blt.w    @do_y

movem.l   (a7)+,d4-d7/a3-a5    ; restore registers
unlk     a6                    ; remove locals
rts      ; return

```

ENDFUNC

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Engineering:KlicsCode:CompPict:Colour.a

```

macro
RGB2Y      =  &RGB,&Y,&U,&V,&AY

move.l     &RGB,d2                ; pixel=*pixmap
ecr1.l     $808080,d2            ; pixel^=0x808080
clr.w      d1                     ; B=0
move.b     d2,d1                 ; B=pixel[3]
move.l     4(a4,d1.w*8),d0       ; d0=by,bu
sub.w      d0,&U                 ; U=-bu
swap       d0                    ; d0=bu,by
move.w     d0,&Y                 ; Y=by
ext.w      d1                    ; (short)B
add.w      d1,d1                 ; B*=2
add.w      d1,&V                 ; V+=B<<1
lsr.l      #8,d2                 ; pixel>>=8
clr.w      d1                     ; G=0
move.b     d2,d1                 ; G=pixel[3]
move.l     (a4,d1.w*8),d0       ; d0=gry,gv
sub.w      d0,&U                 ; U=-gv
swap       d0                    ; d0=gv,gry
sub.w      d0,&Y                 ; Y=-gry
move.l     4(a4,d1.w*8),d0       ; d0=gby,gu
sub.w      d0,&V                 ; V=-gv
swap       d0                    ; d0=gu,gby
sub.w      d0,&Y                 ; Y=-gby
ext.w      d1                    ; (short)G
sub.w      d1,&U                 ; U=-g
sub.w      d1,&V                 ; V=-g
lsr.l      #2,d1                 ; G<<=2
add.w      d1,&Y                 ; Y+=B<<1
lsr.l      #8,d2                 ; pixel>>=8
move.l     (a4,d2.w*8),d0       ; d0=ry,rv
sub.w      d0,&V                 ; V=-rv
swap       d0                    ; d0=rv,ry
add.w      d0,&Y                 ; Y+=ry
ext.w      d2                    ; (short)R
add.w      d2,d2                 ; R*=2
add.w      d2,&U                 ; U+=R<<2
cmpl.w     $FE40,&Y              ; Y>=-448
bge.s      @ok                  ; if greater
move.w     $FE40,&Y              ; Y=-448
bra.s      @end                 ; save
@ok        cmpl.w     $01C0,&Y    ; Y< 448
           blt.s      @end        ; if less
@end       move.w     $01C0,&Y    ; Y= 443
           move.w     &Y,&AY      ; Save Y

endm

```

IN32	FUNC	EXPORT
PS	RECORD	8
table	DS.L	1
pixmap	DS.L	1
Y	DS.L	1
U	DS.L	1
V	DS.L	1
width	DS.L	1
height	DS.L	1
rowByte	DS.L	1
	ENDR	
LS	RECORD	0,DECR

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Engineering:KlicsCode:CompPict:Colour.a

```

Y1      DS.L      = 1      ; sizeof(short)*Yrow      = 2*width
U_ex    DS.L      1      ; x end address      = U+U_ix
U_ey    DS.L      1      ; y end address      = U+width*height>>
U_ix    DS.L      1      ; sizeof(short)*UVrow    = width
Y_y     DS.L      1      ; sizeof(short)*Yrow    = 2*width
P_y     DS.L      1      ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize   EQU       .
ENDR

```

```

a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

```

```

link      a6, #LS.LSize      ; inc, width, fend and rowend are loca
movem.l   d4-d7/a3-a5, -(a7) ; store registers

move.l    PS.Y(a6), a0      ; Y=Yc
move.l    PS.U(a6), a1      ; U=Uc
move.l    PS.V(a6), a2      ; V=Vc
move.l    PS.pixmap(a6), a3 ; pm=pixmap
move.l    PS.table(a6), a4  ; tab=table

move.l    PS.width(a6), d0   ; LOAD width
move.l    d0, LS.U_ix(a6)    ; SAVE U_ix
move.l    PS.height(a6), d1  ; LOAD height
mulu.w    d0, d1             ; width*height
lsr.l     #1, d1             ; width*height/2
add.l     a1, d1             ; U+width*height/2
move.l    d1, LS.U_ey(a6)    ; SAVE U_ey
add.l     d0, d0             ; width*2
move.l    d0, LS.Y1(a6)      ; SAVE Y1
move.l    d0, LS.Y_y(a6)     ; SAVE Y_y
add.l     d0, d0             ; width*4
move.l    PS.rowByte(a6), d1 ; LOAD rowBytes
add.l     d1, d1             ; rowBytes*2
sub.l     d0, d1             ; rowBytes*2-width*4
move.l    d1, LS.P_y(a6)     ; SAVE P_y

moveq.l   PS.rowByte(a6), d7 ; load rowBytes
move.l    LS.Y1(a6), d6      ; load Y1

@do_y     move.l    LS.U_ix(a6), d0 ; LOAD U_ixB
add.l     a1, d0             ; P+U_ixB
move.l    d0, LS.U_ex(a6)    ; SAVE U_exB

@do_x     clr.w     d4        ; U=0
clr.w     d5        ; V=0

RGB2Y     (a3, d7.w), d3, d4, d5, (a0, d6.w); Convert pixel
RGB2Y     (a3)+, d3, d4, d5, (a0)+ ; Convert pixel
RGB2Y     (a3, d7.w), d3, d4, d5, (a0, d6.w); Convert pixel
RGB2Y     (a3)+, d3, d4, d5, (a0)+ ; Convert pixel

asr.w     #2, d4             ; U>>=2
asr.w     #2, d5             ; V>>=2

cmpi.w    #SFE40, d4         ; U>=-448
bge.s     @okU              ; if greater
move.w    #SFE40, d4         ; U=-448
bra.s     @doV              ; save
@okU      cmpi.w    #S01C0, d4 ; U< 448
blt.s     @doV              ; if less
move.w    #S01C0, d4         ; U= 448

```

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Engineering:KlicsCode:CompPict:Colour.a

```

@doV    cmpi.w    >    #SFE40,d5            ; V>=-448
        bge.s     @okV                      ; if greater
        move.w    #SFE40,d5                ; V= -448
        bra.s     @end                      ; save
@okV     cmpi.w    #S01CC,d5                ; V< 448
        blt.s     @end                      ; if less
        move.w    #S01C0,d5                ; V= 448

@end     move.w    d4,(a1)+                  ; Save U
        move.w    d5,(a2)+                  ; Save V

        cmpa.l    LS.U_ex(a6),a1
        blt.w     @do_x

        add.l     LS.Y_y(a6),a0
        add.l     LS.P_y(a6),a3

        cmpa.l    LS.U_ey(a6),a1
        blt.w     @do_y

        movem.l   (a7)+,d4-d7/a3-a5        ; restore registers
        unlk      a6                      ; remove locals
        rts       ; return

```

ENDFUNC

```

macro
UV16      &AU, &AV, &SP, &UV

```

```

        move.l    (&AU)+,&SP
        move.l    (&AV)+,&UV
        UVOVER    &SP,&UV
        lsr.l     #5,&UV
        andi.l    #03e003e0,&SP
        andi.l    #001f001f,&UV
        or.l      &SP,&UV                  ; UV==000UV00UV
        swap      &UV

```

endm

```

macro
Y16x2     &AY,&IND,&UV

```

```

        move.l    &AY,d2                    ; (2+) Y=Y0Y1
        lsl.l     #5,d2                    ; (4) Y=Y0XXY1XX
        andi.l    #SFC00FC00,d2           ;
        or.w      &UV,d2                    ; (2) Y=Y1UV
        move.l    (&IND,d2.w*4),d1         ; (2+) d1=0123 (Y1)
        swap      d2                       ; (4) Y=Y0XX
        or.w      &UV,d2                    ; (2) Y=Y0UV
        move.l    (&IND,d2.w*4),d2         ; (2+) d2=0123 (Y0)

```

endm

OUT16x2 FUNC EXPORT

```

PS      RECORD      8
table   DS.L         1
pixmap  DS.L         1
Y       DS.L         1
U       DS.L         1
V       DS.L         1

```

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Engineering:KlicsCode:CompPict:Colour.a

```

width DS.L      P
height DS.L     1
rowByte DS.L    1
pixmap2 DS.L    1
ENDR

.
LS      RECORD      0,DECR
Y1      DS.L        1      ; sizeof(short)*Yrow      = 2*width
U_ex    DS.L        1      ; x end address      = U+U_ix
U_ey    DS.L        1      ; y end address      = U+width*height>>
U_ix    DS.L        1      ; sizeof(short)*UVrow = width
Y_y     DS.L        1      ; sizeof(short)*Yrow  = 2*width
P_y     DS.L        1      ; 4*rowBytes-sizeof(long)*Prow = 4*rowBytes-width
LSize   EQU
ENDR

.
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link      a6,#LS.LSize      ; inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7) ; store registers

move.l    PS.Y(a6),a0      ; Y=Yc
move.l    PS.U(a6),a1      ; U=Uc
move.l    PS.V(a6),a2      ; V=Vc
move.l    PS.pixmap(a6),a3 ; pm=pixmap
move.l    PS.table(a6),a4   ; tab=table
adda.l    #00020000,a4      ; tab+=32768 (longs)
move.l    PS.pixmap2(a6),a5 ; pm2=pixmap2

move.l    PS.width(a6),d0   ; LOAD width
move.l    d0,LS.U_ix(a6)    ; SAVE U_ix
move.l    PS.height(a6),d1  ; LOAD height
mulu.w    d0,d1             ; width*height
lsr.l     #1,d1             ; width*height/2
add.l     a1,d1             ; U+width*height/2
move.l    d1,LS.U_ey(a6)    ; SAVE U_ey
add.l     d0,d0             ; width*2
move.l    d0,LS.Y1(a6)      ; SAVE Y1
move.l    d0,LS.Y_y(a6)     ; SAVE Y_y
add.l     d0,d0             ; width*4
move.l    PS.rowByte(a6),d1 ; LOAD rowBytes
add.l     d1,d1             ; rowBytes*2
add.l     d1,d1             ; rowBytes*4
sub.l     d0,d1             ; rowBytes*4-width*4
move.l    d1,LS.P_y(a6)     ; SAVE P_y

move.l    PS.rowByte(a6),d5 ; load rowBytes
clr.l     d6
clr.l     d7

@do_y     move.l    LS.U_ix(a6),d0      ; LOAD U_ixB
add.l     a1,d0                      ; P+U_ixB
move.l    d0,LS.U_ex(a6)              ; SAVE U_exB

@do_x     GETOV      a1,a2,d0,d4      ; d4=00UV00UV (1G)

GETY
move.l    (a0),a4,d4,d1,d2           ; calc d2,d1 pixel
move.l    d2,(a3)+
move.l    d1,(a3)
add.l     d5,a3
swap      d1
move.l    d1,(a3)

```

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Engineering:KlicsCode:CcmpPict:Colour.a

```

swap      d2
move.l    d2, -(a3)
add.l     d5, a3

move.l    LS.Y1(a6), d0      ; load Yrow
GETY      (a0, d0.w), a4, d4, d1, d2 ; calc d2, d1 pixels
move.l    d2, (a3)+
move.l    d1, (a3)
add.l     d5, a3
swap      d1
move.l    d1, (a3)
swap      d2
move.l    d2, -(a3)

swap      d4                  ; next UV
addq.l    #4, a0              ; next Ys
add.l     #12, a3

move.l    LS.Y1(a6), d0      ; load Yrow
GETY      (a0, d0.w), a4, d4, d1, d2 ; calc d2, d1 pixels
move.l    d1, (a3)
move.l    d2, -(a3)
sub.l     d5, a3
swap      d2
move.l    d2, (a3)+
swap      d1
move.l    d1, (a3)
sub.l     d5, a3

GETY      (a0)+, a4, d4, d1, d2
move.l    d1, (a3)
move.l    d2, -(a3)
swap      d2
sub.l     d5, a3
move.l    d2, (a3)+
swap      d1
move.l    d1, (a3)+

cmpa.l    LS.U_ex(a6), a1
blt.w     @do_x

add.l     LS.Y_y(a6), a0
add.l     LS.P_y(a6), a3

cmpa.l    LS.U_ey(a6), a1
blt.w     @do_y

movem.l   (a7)+, d4-d7/a3-a5 ; restore registers
unlk      a6                  ; remove locals
rts       ; return

```

ENDFUNC

```

-----
macro
Y16      &AY, &IND, &UV

move.l    &AY, d2
lsl.l     #5, d2              ; (2+) Y=Y0Y1
andi.l    #SPC00FC00, d2      ; (4) Y=Y0XXY1XX
or.w      &UV, d2              ; (2) Y=Y1UV
move.l    (&IND, d2.w*4), d1   ; (2+) d1=Y1
swap      d2                  ; (4) Y=Y0XX
or.w      &UV, d2              ; (2) Y=Y0UV

```

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Engineering:KlicsCode:CompPict:Colour.a

```

move.l    (&IND,d2,w*4),d2      ; (2-) d2=Y0
move.w    d1,d2                 ; (2) d2=Y0Y1
endm

CUT16     FUNC      EXPORT
*
PS        RECORD      8
table     DS.L        1
pixmap    DS.L        1
Y         DS.L        1
U         DS.L        1
V         DS.L        1
width     DS.L        1
height    DS.L        1
rowByte   DS.L        1
pixmap2   DS.L        1
ENDR

LS        RECORD      0,DECR
Y1        DS.L        1          ; sizeof(short)*Yrow      = 2*width
U_ex      DS.L        1          ; x end address          = U+U_ix
U_ey      DS.L        1          ; y end address          = U+width*height>>
U_ix      DS.L        1          ; sizeof(short)*UVrow    = width
Y_y       DS.L        1          ; sizeof(short)*Yrow     = 2*width
P_y       DS.L        1          ; 2*rowBytes-sizeof(long)*Prow = 2*rowBytes-width
LSize     EQU
ENDR

*
a0 - Y, a1 - U, a2 - V, a3 - pixmap, a4 - table, a5 - pixmap2
d0 - rgb00, d1 - rgb01, d2 - rgb10, d3 - rgb11, d4 - spare, d6 - old0, d7

link      a6,#LS.LSize          ; inc, width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7)     ; store registers

move.l    PS.Y(a6),a0           ; Y=Yc
move.l    PS.U(a6),a1           ; U=Uc
move.l    PS.V(a6),a2           ; V=Vc
move.l    PS.pixmap(a6),a3      ; pm=pixmap
move.l    PS.table(a6),a4       ; tab=table
adda.l    #S00020000,a4         ; tab+=32768 (longs)
move.l    PS.pixmap2(a6),a5     ; pm2=pixmap2

move.l    PS.width(a6),d0       ; LOAD width
move.l    d0,LS.U_ix(a6)        ; SAVE U_ix
move.l    PS.height(a6),d1      ; LOAD height
mulu.w    d0,d1                 ; width*height
lsr.l     #1,d1                 ; width*height/2
add.l     a1,d1                 ; U+width*height/2
move.l    d1,LS.U_ey(a6)        ; SAVE U_ey
add.l     d0,d0                 ; width*2
move.l    d0,LS.Y1(a6)          ; SAVE Y1
move.l    d0,LS.Y_y(a6)         ; SAVE Y_y
move.l    PS.rowByte(a6),d1     ; LOAD rowBytes
add.l     d1,d1                 ; rowBytes*2
sub.l     d0,d1                 ; rowBytes*2-width*2
move.l    d1,LS.P_y(a6)         ; SAVE P_y

move.l    PS.rowByte(a6),d5     ; load rowBytes
clr.l     d6
clr.l     d7

@do_y     move.l    LS.U_ix(a6),d0 ; LOAD U_ixB

```

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Engineering:KlicsCode:CompPict:Colour.a

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```

add.l    a1,d0          ; P+U_ixB
move.l    d0,LS_U_ex(a6) ; SAVE U_exB
edo_x GETUV             a1,a2,d0,d4      ; d4=00UV00UV (10)
GETY      (a0),a4,d4,d1,d2 ; calc d2,d1 pixel
move.w    d1,d2
move.l    d2,(a3)
add.l     d5,a3

move.l    LS.Y1(a6),d0    ; load Yrow
GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
move.w    d1,d2
move.l    d2,(a3)+

swap      d4              ; next UV
addq.l    #4,a0           ; next Ys

move.l    LS.Y1(a6),d0    ; load Yrow
GETY      (a0,d0.w),a4,d4,d1,d2 ; calc d2,d1 pixels
move.w    d1,d2
move.l    d2,(a3)
sub.l     d5,a3

GETY      (a0)+,a4,d4,d1,d2
move.w    d1,d2
move.l    d2,(a3)+

cmpa.l    LS_U_ex(a6),a1
blt.w     edo_x

add.l     LS.Y_y(a6),a0
add.l     LS.P_y(a6),a3

cmpa.l    LS_U_ey(a6),a1
blt.w     edo_y

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6                ; remove locals
rts       ; return

ENDFUNC
-----
END

```

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Engineering:KlicsCode:CompPict:Color2:a

```

-----
*   © Copyright 1993 KLICS Limited
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```

```

*   Written by: Adrian Lewis
-----

```

```

*   68000 Fast RGB/YUV code
-----

```

```

include 'Traps.a'
machine mc68030
-----

```

```

macro
RGB2Y    &Apixel,&AY
:
:   d0 - pixel/r, d1 - g/2g+r, d2 - b, d3 - Y
:
:   move.l    &Apixel,d0      ; pixel=*Apixel
:   eor.l     #S00808080,d0   ; signed pixels
:
:   move.b    d0,d2           ; b=pixel[3]
:   ext.w     d2              ; b is 8(16) bit
:
:   move.w    d0,d1           ; g=pixel[2]
:   asr.w     #7,d1           ; 2g is 9(16) bit
:
:   swap      d0              ; r=pixel[1]
:   ext.w     d0              ; r is 8(16) bit
:
:   move.w    d2,d3           ; Y=b
:   lsl.w     #3,d3           ; Y<<=3
:   sub.w     d2,d3           ; Y-=b
:
:   add.w     d0,d1           ; 2g+=r
:   add.w     d1,d3           ; Y+=2g+r
:   add.w     d1,d3           ; Y+=2g+r
:   add.w     d1,d3           ; Y+=2g+r
:   asr.w     #4,d3           ; Y>>=4
:   add.w     d1,d3           ; Y+=2g+r
:   move.w    d3,&AY          ; AY=Y is 10(16) bit
:
endm
-----

```

```

macro
RGB2UV    &AU,&AV
:
:   d0 - r, d2 - b, d3 - Y, d1 - U/V
:
:   add.w     d0,d0           ; r is 9(16) bit
:   add.w     d2,d2           ; b is 9(16) bit
:   asr.w     #1,d3           ; Y is 9(16) bit
:   move.w    d2,d1           ; U=b
:   sub.w     d3,d1           ; U=b-Y
:   move.w    d1,&AU          ; AU=U
:   move.w    d0,d1           ; V=r
:   sub.w     d3,d1           ; V=r-Y
:   move.w    d1,&AV          ; AV=V
:
endm
-----

```


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Engineering:KlicsCode:CompPict:Color2.a

```

if &TYPE('seg')!='UNDEFINED' then
seg      &seg
endif

RGB2YUV2    FUNC      EXPORT
.
    link      a6,#0          ; no local variables
    movem.l   d4-d7/a3,-(a7) ; store registers
.
    move.l    $0008(a6),a3    ; pm=pixmap
    move.l    $000C(a6),a0    ; Y=Yc
    move.l    $0010(a6),a1    ; U=Uc
    move.l    $0014(a6),a2    ; V=Vc
    move.l    $0018(a6),d7    ; fend=area
    asl.l     #2,d7           ; fend<=2
    add.l     a3,d7           ; fend+=pm
    move.l    $001C(a6),d4    ; width_b=width
    asl.l     #2,d4           ; width_b<=2
    move.l    $0020(a6),d5    ; inc_b=cols
    asl.l     #2,d5           ; cols<=2
    sub.l     d4,d5           ; inc_b-=width_b
@do1        move.l    a3,d6    ; rowend=pm
    add.l     d4,d6           ; rowend+=width_b
@do2        rgb2y     (a3)+,(a0)+ ; rgb2y(pm++,Y++)
    rgb2uv    (a1)+,(a2)+ ; rgb2uv(U++,V++)
    rgb2y     (a3)+,(a0)+ ; rgb2y(pm++,Y++)
    cmpa.l    d6,a3          ; rowend>pm
    blt.s     @do2           ; while
    adda.l    d5,a3          ; pm+=inc_b
    move.l    a3,d6          ; rowend=pm
    add.l     d4,d6          ; rowend+=width_b
@do3        rgb2y     (a3)+,(a0)+ ; rgb2y(pm++,Y++)
    cmpa.l    d6,a3          ; rowend>pm
    blt.s     @do3           ; while
    adda.l    d5,a3          ; pm+=inc_b
    cmpa.l    d7,a3          ; fend>pm
    blt.w     @do1           ; while
.
    movem.l   (a7)+,d4-d7/a3  ; restore registers
    unlk      a6              ; remove locals
    rts
.
ENDFUNC
-----
macro
FETCHY      &AY, &Y, &R, &G, &B
.
    move.l    &AY,&Y          ; Y=*AY++
    add.l     &Y,&R           ; RR+=Y12
    add.l     &Y,&G           ; GG+=Y12
    add.l     &Y,&B           ; BB+=Y12
.
endm
-----
macro
FIXOV      &V, &SP1, &SP2
.
    move.w    &V,&SP1
    clr.b     &SP1
    andi.w    #$3FFF,&SP1
    sne       &SP1
    btsr      #13,&SP1
    seq       &SP2
.

```

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Engineering:KlidsCode:CompPict:Color2.a

```

or.b    &SP1,&V
and.w   &SP2,&V
swap    &V
move.w  &V,&SP1
clr.b   &SP1
andi.w  *$FFFF,&SP1
sne     &SP1
btst    *13,&SP1
seq     &SP2
or.b    &SP1,&V
and.w   &SP2,&V
swap    &V
endm

-----
macro
OVERFLOW    &A, &B, &SP1, &SP2
.
.   move.l    #SFF0FF00,&SP1          ; spl=mask
.   move.l    &A,&SP2                  ; sp2=ovcv (A)
.   and.l     &SP1,&SP2                ; sp2=o0o0 (A)
.   lsr.l     #8,&SP2                  ; sp2=0o0o (A)
.   and.l     &B,&SP1                  ; spl=o0o0 (B)
.   or.l      &SP2,&SP1                ; spl=oooo (BABA)
.   move.l    &A,&SP1
.   or.l      &B,&SP1
.   andi.l    #SFF0FF00,&SP1
.   beq.s     @ok                      ; if no overflow
.   clr.w     &SP2                      ; AND=0
.   FIXOV     &A,&SP1,&SP2              ; A1 overflow
.   FIXOV     &B,&SP1,&SP2              ; B1 overflow
@ok
.
endm

-----
macro
MKRGB      &R, &G, &B, &ARGB
.
.   lsl.l     #8,&G                    ; G=G0G0 (12)
.   or.l      &B,&G                    ; G=GBGB (12)
.   move.l    &R,&B                    ; B=0R0R (12)
.   swap      &B                      ; B=0R0R (21)
.   move.w    &G,&B                    ; B=0RGB (2)
.   swap      &G                      ; G=GBGB (21)
.   move.w    &G,&R                    ; R=0RGB (1)
.   move.l    &R,&ARGB                 ; *RGB++=rgb (1)
.   move.l    &B,&ARGB                 ; *RGB++=rgb (2)
.
endm

-----
macro
DUPVAL     &V0, &V1
.
.   move.w    &V0,&V1                  ; v1=v0
.   swap      &V0                      ;
.   move.w    &V1,&V0                  ; dup v0
.   move.l    &V0,&V1                  ; dup v1
.
endm

-----
macro
UV2RGB3    &AU,&AV

```

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Engineering:KlicsCode:CompPict:Color2.a

```

d1 - ra, d2 - ga, d3 - ba, d4 - rb, d5 - gb/512, d6 - bb
    =>
move.w    #512,d5          ; d5=512
move.w    &AU,d2           ; U=*AU++
add.w     d2,d2            ; U is 10(16) bits
move.w    d2,d3           ; ba=U
add.w     d3,d2            ; ga=2U
add.w     d3,d2            ; ga=3U
add.w     d5,d3            ; ba+=512
DUPVAL    d3,d6            ; ba=bb=BB
asr.w     #4,d2            ; ga=3U>>4
move.w    &AV,d1           ; V=*AV++
add.w     d1,d2            ; ga+=V
add.w     d1,d1            ; ra*=2
add.w     d5,d1            ; ra+=512
DUPVAL    d1,d4            ; ra=rb=RR
sub.w     d2,d5            ; gb=512-ga
DUPVAL    d5,d2            ; ga=gb=GG

```

endm

```

-----
if &TYPE('seg')!='UNDEFINED' then
seg    &seg
endif

```

YUV2RGB2 FUNC EXPORT

```

PS      RECORD      8
pixmap  DS.L         1
Y        DS.L         1
U        DS.L         1
V        DS.L         1
area     DS.L         1
width    DS.L         1
cols     DS.L         1
        ENDR

```

```

LS      RECORD      0,DECR
inc      DS.L         1
width    DS.L         1
fend     DS.L         1
count    DS.L         1
LSize    EQU          *
        ENDR

```

```

a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
d0..6 - used, d7 - count

```

```

link      a6,#LS.LSize      ; inc, width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7) ; store registers

move.l    PS.pixmap(a6),a4   ; pm0=pixmap
move.l    a4,a5              ; pm1=pm0
move.l    PS.Y(a6),a0        ; Y0=Yc
move.l    a0,a1              ; Y1=Y0
move.l    PS.U(a6),a2        ; U=Uc
move.l    PS.V(a6),a3        ; V=Vc
move.l    PS.area(a6),d7     ; fend=area
lsl.l     #2,d7              ; fend<=2
add.l     a4,d7              ; fend+=pm0
move.l    d7,LS.fend(a6)     ; save fend
move.l    PS.width(a6),d5    ; width=width
move.l    d5,d7              ; count=width

```

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Engineering: KlicsCode: CompPict: Color2.a

```

asr.l      #1,d7          ; count>=1
subq.l     #1,d7          ; count-=1
move.l     d7,PS,width(a6) ; save width
add.l      d5,d5          ; width*=2
add.l      d5,a1          ; Y1+=width
add.l      d5,d5          ; width*=2
move.l     d5,LS,width(a6) ; save width
move.l     PS,cols(a6),d4 ; inc=cols
lsl.l      #2,d4          ; inc<=2
add.l      d4,a5          ; pml+=inc
add.l      d4,d4          ; cols*=2
sub.l      d5,d4          ; inc now 2*cols-width bytes
move.l     d4,LS,inc(a6)   ; save inc
@do        UV2RGB3        ; uv2rgb(*U++,*V++)
FETCHY     (a0)+,d0,d1,d2,d3 ; add Ya to RGB values
FETCHY     (a1)+,d0,d4,d5,d6 ; add Yb to RGB values
move.w     #S3FFF,d0      ; d0=mask
lsl.l      #2,d1          ; d1 8(16) bits
and.w      d0,d1          ; d1 masked
lsl.l      #2,d2          ; d2 8(16) bits
and.w      d0,d2          ; d2 masked
lsl.l      #2,d3          ; d3 8(16) bits
and.w      d0,d3          ; d3 masked
lsl.l      #2,d4          ; d4 8(16) bits
and.w      d0,d4          ; d4 masked
lsl.l      #2,d5          ; d5 8(16) bits
and.w      d0,d5          ; d5 masked
lsl.l      #2,d6          ; d6 8(16) bits
and.w      d0,d6          ; d6 masked
move.l     d1,d0
or.l       d2,d0
or.l       d3,d0
or.l       d4,d0
or.l       d5,d0
or.l       d6,d0
andi.l     #SFFF00FF00,d0
bne.s      @over
@ok        MKRGB          ; if overflow
MKRGB      d1,d2,d3,(a4)+ ; save RGBa
MKRGB      d4,d5,d6,(a5)+ ; save RGBb
dbf        d7,@do        ; while
adda.l     LS,inc(a6),a4   ; pm0+=inc
adda.l     LS,inc(a6),a5   ; pml+=inc
adda.l     LS,width(a6),a0 ; Y0+=width
exg.l      a0,a1          ; Y1<->Y0
move.l     PS,width(a6),d7 ; count=width
cmpa.l     LS,fend(a6),a4  ; pm0<fend
blt.w      @do            ; while

moven.l    (a7)+,d4-d7/a3-a5 ; restore registers
unlk       a6              ; remove locals
rts        ; return
@over      move.l     d7,LS,count(a6) ; save count
clr.w      d7              ; AND=0

FIXOV      d1,d0,d7        ; A overflow
FIXOV      d2,d0,d7        ; B overflow
FIXOV      d3,d0,d7        ; A overflow
FIXOV      d4,d0,d7        ; B overflow
FIXOV      d5,d0,d7        ; A overflow
FIXOV      d6,d0,d7        ; B overflow
move.l     LS,count(a6),d7 ; restore count
bra        @ok

```

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Engineering:KlacsCode:CompPict:Color2.a

```

ENDFUNC
-----
if &TYPE('seg')='UNDEFINED' then
seg    &seg
endif

GREY2Y  FUNC    EXPORT
.
PS      RECORD    8
pixmap  DS.L      1
Y        DS.L      1
area     DS.L      1
width    DS.L      1
cols     DS.L      1
        ENDR
.
d0 - vvvv, d1 - v0v1, d2 - v2v3, d3 - xor, d4 - width, d5 - inc, d6 - rowend,
a0 - pm, a1 - Y
.
        link      a6,#0                ; no local variables
        movem.l   d4-d7,-(a7)          ; store registers
.
        move.l    PS.pixmap(a6),a0     ; pm=pixmap
        move.l    PS.Y(a6),a1          ; Y=Yc
        move.l    PS.area(a6),d7       ; fend=area
        add.l     a0,d7                 ; fend+=pm
        move.l    PS.width(a6),d4      ; width_b=width
        move.l    PS.cols(a6),d5       ; inc_b=cols
        sub.l     d4,d5                 ; inc_b-=width_b
        move.l    $7F7F7F7F,d3         ; xor=$7F7F7F7F
@do1     move.l    a0,d6                 ; rowend=pm
        add.l     d4,d6                 ; rowend+=width_b
@do2     move.l    (a0)+,d0              ; vvvv=pm
        eor.l     d3,d0                 ; vvvv is signed
        move.w    d0,d2                 ; d2=v2v3
        asr.w     #6,d2                 ; d2=v2 (10 bits)
        swap      d2                    ; d2=v2??-
        move.b    d0,d2                 ; d2=v2v3
        ext.w     d2                    ; v3 extended
        lsl.w     #2,d2                 ; d2=v2v3 (10 bits)
        swap      d0                    ; d0=v0v1
        move.w    d0,d1                 ; d1=v0v1
        asr.w     #6,d1                 ; d1=v0 (10 bits)
        swap      d1                    ; d1=v0??
        move.b    d0,d1                 ; d1=v0v1
        ext.w     d1                    ; v1 extended
        lsl.w     #2,d1                 ; d1=v0v1 (10 bits)
        move.l    d1,(a1)+              ; *Y=d1
        move.l    d2,(a1)+              ; *Y=d2
        cmpa.l    d6,a0                 ; rowend>pm
        blt.s     @do2                  ; while
        adda.l    d5,a0                  ; pm+=inc_b
        cmpa.l    d7,a0                 ; fend>pm
        blt.s     @do1                  ; while
.
        movem.l   (a7)+,d4-d7          ; restore registers
        unlk      a6                    ; remove locals
        rts
.
ENDFUNC
-----
if &TYPE('seg')='UNDEFINED' then
seg    &seg
endif

```

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Engineering: KlicsCode: CompPict: Color2.a

```

endif
Y2GREY FUNC EXPORT
PS RECORD 3
pixmap DS.L 1
Y DS.L 1
height DS.L 1
width DS.L 1
cols DS.L 1
ENDR
.
d0- spare, d1 - v43, d2 - v21, d3 - spare, d4 - width, d5 - inc, d6 - count, d
a0 - pm, a1 - Y
.
link a6, #0 ; no local variables
movem.l d4-d7, -(a7) ; store registers
.
move.l PS.pixmap(a6), a0 ; pm=pixmap
move.l PS.Y(a6), a1 ; Y=Yc
move.l PS.height(a6), d7 ; long height
subq.l #1, d7 ; height--1
move.l PS.width(a6), d4 ; long width
move.l PS.cols(a6), d5 ; long inc=cols
sub.l d4, d5 ; inc-=width
lsr.l #2, d4 ; width>>=2 (read 4 values)
subq.l #1, d4 ; width--1
@dc1 move.l d4, d6 ; count=width
@dc2 move.l (a1)+, d0 ; d0=x4x3
move.l (a1)+, d1 ; d1=x2x1
move.l #501FF01FF, d2 ; d2=511
move.l d2, d3 ; d3=511
sub.l d0, d2 ; unsigned d2
sub.l d1, d3 ; unsigned d3
lsr.l #2, d2
lsr.l #2, d3
move.l d2, d0
or.l d3, d0
andi.l #53F003F00, d0
bne.s @over ; if no overflow
@ok lsl.w #8, d3 ; d3=0210
lsl.w #8, d2 ; d2=0430
lsr.l #8, d3 ; d3=0021
lsl.l #8, d2 ; d2=4300
or.l d3, d2 ; d2=4321
move.l d2, (a0)+ ; *pm=d2
dbf d6, @dc2 ; while -1!--count
adda.l d5, a0 ; pm+=inc_b
dbf d7, @dc1 ; while -1!--height
.
movem.l (a7)+, d4-d7 ; restore registers
unlk a6 ; remove locals
rts ; return
@over clr.w d1 ; AND=0
FIXOV d2, d0, d1 ; A overflow
FIXOV d3, d0, d1 ; B overflow
bra.s @ok
.
ENDFUNC
-----
macro
GCC &V, &SP1, &SP2, &AV

```

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Engineering:KlicsCode:CompPic::Color2.a

```

move.l    &V,&SP2           ; SP2=0102
lsl.l     #8,&SP2           ; SP2=1020
or.l      &V,&SP2           ; SP2=1122
move.l    &V,&SP1           ; SP1=0102
swap      &SP1              ; SP1=0201
move.w    &SP2,&SP1         ; SP1=0222
swap      &SP2              ; SP2=2211
move.w    &SP2,&V           ; V=0111
move.l    &V,&AV            ; *pm=V
move.l    &SP1,&AV          ; *pm=SP1

endm

-----
if &TYPE('seg')!='UNDEFINED' then
seg      &seg
endif

Y2GGG    FUNC      EXPORT
.
PS        RECORD      8
pixmap    DS.L        1
Y          DS.L        1
lines     DS.L        1
width     DS.L        1
cols      DS.L        1
ENDR
.
d0 - v, d4 - width, d5 - inc, d6 - count, d7 - lines
a0 - pm, a1 - Y

link      a6,#0             ; no local variables
movem.l   d4-d7,-(a7)       ; store registers

move.l    PS,pixmap(a6),a0   ; pm=pixmap
move.l    PS,Y(a6),a1        ; Y=Yc
move.l    PS,lines(a6),d7    ; long lines
subq.l    #1,d7              ; lines-=1
move.l    PS,width(a6),d4    ; long width
move.l    PS,cols(a6),d5     ; inc=cols
sub.l     d4,d5              ; inc-=width
lsl.l     #2,d5              ; inc=(bytes)
lsr.l     #2,d4              ; width>>=2
subq.l    #1,d4              ; width-=1
@dc1      move.l    d4,d6     ; count=width
@dc2      move.l    (a1)+,d0   ; d0=x1x2 (10 bits signed)
          move.l    (a1)+,d1   ; d1=x3x4 (10 bits)
          move.l    $02000200,d3 ; d3=plus
          add.l     d3,d0       ; d0=x1x2 (unsigned)
          add.l     d3,d1       ; d1=x3x4 (unsigned)
          lsr.l     #2,d0       ; d0=x1x2 (10,8 bits)
          lsr.l     #2,d1       ; d1=x3x4 (10,8 bits)
          move.w    $3FFF,d2    ; d2=mask
          and.w     d2,d0       ; mask d0
          and.w     d2,d1       ; mask d1
          move.l    d0,d2
          or.l      d1,d2
          andi.l    $FFF0FF00,d2
          bne.s     @over      ; if no overflow
@ok        GGG        d0,d2,d3,(a0)+
          GGG        d1,d2,d3,(a0)+
          dbf       d6,@dc2    ; while -1!--count
          adda.l    d5,a0      ; pm+=inc_b
          dbf       d7,@dc1    ; while -1!--lines

```

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Engineering:KlidsCode:CompPict:Color2.a

```

movem.l    (a7)+,d4-d7      ; restore registers
unlk       a6               ; remove locals
rts        ; return
cover      clr.w            ; AND=0
FIXOV      d0,d2,d3         ; A overflow
FIXOV      d1,d2,d3         ; B overflow
bra.w      @ok

```

ENDFUNC

```

-----
macro
MKRGB2      &R, &G, &B, &ARGB, &ROW, &XX

lsl.l       &B,&G           ; G=G0G0 (12)
or.l        &B,&G           ; G=GBGB (12)
move.l      &R,&B          ; B=0R0R (12)
swap       &B              ; B=0R0R (21)
move.w      &G,&B          ; B=0RGB (2)
swap       &G              ; G=GBGB (21)
move.w      &G,&R          ; R=0RGB (1)

andi.l      *SFFFEFEFE,&R   ; 7 bits for interpolation
andi.l      *SFFFEFEFE,&B   ; 7 bits for interpolation

move.l      &R,&G           ; G=RGB(1)
add.l       &B,&G           ; G+=RGB(2)
lsr.l       #1,&G           ; G/=2

move.l      &B,&XX          ; XX=RGB(2)
sub.l       &R,&XX          ; XX-=RGB(1)
lsr.l       #1,&XX          ; XX/=2
add.l       &B,&XX          ; XX+=8

move.l      &R,(&ARGB)+     ; *RGB++=rgb (1)
move.l      &G,(&ARGB)+     ; *RGB++=rgb (1.5)
move.l      &B,(&ARGB)+     ; *RGB++=rgb (2)
move.l      &B,(&ARGB)+     ; *RGB++=rgb (2.5)

add.l       &ROW,&ARGB
sub.l       #16,&ARGB

move.l      &R,(&ARGB)+     ; *RGB++=rgb (1)
move.l      &G,(&ARGB)+     ; *RGB++=rgb (1.5)
move.l      &B,(&ARGB)+     ; *RGB++=rgb (2)
move.l      &B,(&ARGB)+     ; *RGB++=rgb (2.5)

sub.l       &ROW,&ARGB

```

endm

```

-----
if &TYPE('seg')=UNDEFINED then
seg      &seg
endif

```

YUV2RGB3	FUNC	EXPORT
PS	RECORD	8
pixmap	DS.L	1
Y	DS.L	1
U	DS.L	1
V	DS.L	1
area	DS.L	1

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Engineering:KlacsCode:CompPict:Color2.a

```

width    DS.L      1
cols     DS.L      1
        ENDR
.
LS        RECORD    0,DECR
inc       DS.L      1
width     DS.L      1
fend      DS.L      1
count     DS.L      1
row       DS.L      1
LSize     EQU       *
        ENDR
.
        a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pml
        d0..6 - used, d7 - count
.
        link        a6, #LS.LSize          ; inc. width, fend and rowend are loca
        movem.l     d4-d7/a3-a5, -(a7)      ; store registers
.
        move.l      PS.pixmap(a6), a4      ; pm0=pixmap
        move.l      a4, a5                  ; pml=pml0
        move.l      PS.Y(a6), a0            ; Y0=Yc
        move.l      a0, a1                  ; Y1=Y0
        move.l      PS.U(a6), a2            ; U=Uc
        move.l      PS.V(a6), a3            ; V=Vc
        move.l      PS.area(a6), d7         ; fend=area
        lsl.l       #2, d7                  ; fend<=2
        add.l       a4, d7                  ; fend+=pm0
        move.l      d7, LS.fend(a6)         ; save fend
        move.l      PS.width(a6), d5        ; width=width
        move.l      d5, d7                  ; count=width
        asr.l       #1, d7                  ; count>>=1
        subq.l      #1, d7                  ; count-=1
        move.l      d7, PS.width(a6)        ; save width
        add.l       d5, d5                  ; width*=2
        add.l       d5, a1                  ; Y1+=width
        add.l       d5, d5                  ; width*=2
        move.l      d5, LS.width(a6)        ; save width
        move.l      PS.cols(a6), d4         ; inc=cols
        lsl.l       #2, d4                  ; inc<=2
        move.l      d4, LS.row(a6)          ; *NEW save row
        add.l       d4, a5                  ; pml+=inc
        add.l       d4, a5                  ; *NEW pml+=inc
        add.l       d4, d4                  ; cols*=2
        add.l       d4, d4                  ; *NEW cols*=2
        sub.l       d5, d4                  ; inc now 4*cols-width bytes
        sub.l       d5, d4                  ; *NEW inc now 4*cols-width bytes (wid
        move.l      d4, LS.inc(a6)          ; save inc
@do      UV2RGB3    (a2)+, (a3)+           ; uv2rgb(*U++, *V++)
.
        FETCHY      (a0)+, d0, d1, d2, d3   ; add Ya to RGB values
        FETCHY      (a1)+, d0, d4, d5, d6   ; add Yb to RGB values
.
        move.w       #03FFF, d0             ; d0=mask
        lsr.l       #2, d1                  ; d1 8(16) bits
        and.w        d0, d1                 ; d1 masked
        lsr.l       #2, d2                  ; d2 8(16) bits
        and.w        d0, d2                 ; d2 masked
        lsr.l       #2, d3                  ; d3 8(16) bits
        and.w        d0, d3                 ; d3 masked
        lsr.l       #2, d4                  ; d4 8(16) bits
        and.w        d0, d4                 ; d4 masked
        lsr.l       #2, d5                  ; d5 8(16) bits

```

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Engineering:KlidesCode:CompPict:Color3.a

```

and.w    d0,d5          ; d5 masked
lsr.l    #2,d5          ; d6 8(16) bits
and.w    d0,d6          ; d6 masked

move.l    d1,d0
or.l     d2,d0
or.l     d3,d0
or.l     d4,d0
or.l     d5,d0
or.l     d6,d0
andi.l    #5FFF00FF00,d0
bne.w     @over          ; if overflow

9ok      MKRGB2    d1,d2,d3,a4,LS.row(a6),d0    ; *NEW save RGBa
MKRGB2    d4,d5,d6,a5,LS.row(a6),d0    ; *NEW save RGBb
dbf       d7,@do         ; while
adda.l    LS.inc(a6),a4    ; pm0+=inc
adda.l    LS.inc(a6),a5    ; pm1+=inc
adda.l    LS.width(a6),a0  ; Y0+=width
exg.l     a0,a1           ; Y1<->Y0
move.l    PS.width(a6),d7 ; count=width
cmpa.l    LS.fend(a6),a4   ; pm0<fend
blt.w     @do             ; while

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6              ; remove locals
rts       ; return
3over     move.l    d7,LS.count(a6) ; save count
clr.w     d7              ; AND=0
FIXOV     d1,d0,d7        ; A overflow
FIXOV     d2,d0,d7        ; B overflow
FIXOV     d3,d0,d7        ; A overflow
FIXOV     d4,d0,d7        ; B overflow
FIXOV     d5,d0,d7        ; A overflow
FIXOV     d6,d0,d7        ; B overflow
move.l    LS.count(a6),d7 ; restore count
bra       @ok

-----
ENDFUNC
-----
macro
FETCHY2    &AY, &Y, &R, &G, &B
; Y

move.l     &AY,&Y
asr.w     #2,&Y
swap      &Y
asr.w     #2,&Y
swap      &Y
add.l     &Y,&R
add.l     &Y,&G
add.l     &Y,&B
; Y is      -128 to +127
; RED: Get (Y+ 2V + 512) for Red = (Y +
; GREEN: Get (Y + (512 - (6U/16)) - V)
; BLUE: Get (Y + (2U + 512) for Blue = (

endm
-----
macro
UV2RGB4    &AU,&AV
; U
move.w     &AU,d2
and.w     #503FF,d2
move.l     (a6,d2.w*8),d3
move.l     d3,d6
move.l     4(a6,d2.w*8),d5
move.w     &AV,d1
; V
BLUE: Get (2U + 512)/4 for Blue = (Y +
Dup for second pair
GREEN: Get (512 - (6U/16))/4 for Gree

```

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Engineering:Kl:csCode:CompPict:Color2.a

```

move.w    d1,d4
asr.w     #2,d1
sub.w     d1,d5      ; GREEN, Get (512 - (60/16) - V)/4 for
move.w     d5,d2
swap      d5
move.w     d2,d5
move.l     d5,d2      ; Dup for second pair

and.w     #03FF,d4
move.l     (a6,d4.w*8),d4      ; RED, Get (2V + 512)/4 for Red = (Y +
move.l     d4,d1

-----
endm

```

MKRGB2SUB FUNC EXPORT

```

MKRGB2    d1,d2,d3,a4,d7,d0      ; NEW save RGBa
MKRGB2    d4,d5,d6,a5,d7,d0      ; NEW save RGBb
rts

```

ENDFUNC

OVERSUB FUNC EXPORT

```

move.l     d1,d0
or.l       d2,d0
or.l       d3,d0
or.l       d4,d0
or.l       d5,d0
or.l       d6,d0
andi.l     #FFF0FF00,d0
bne.s      @over      ; if overflow
@ok
rts
@over
move.l     d7,-(sp)      ; save count
clr.w      d7           ; AND=0
FIXOV      d1,d0,d7      ; A overflow
FIXOV      d2,d0,d7      ; B overflow
FIXOV      d3,d0,d7      ; A overflow
FIXOV      d4,d0,d7      ; B overflow
FIXOV      d5,d0,d7      ; A overflow
FIXOV      d6,d0,d7      ; B overflow
move.l     (sp)+,d7      ; restore count
bra        @ok

```

ENDFUNC

UV2RGB4SUB FUNC EXPORT

```

UV2RGB4    (a2)+,(a3)+      ; uv2rgb(*U++,*V++)
rts

```

ENDFUNC

FETCHY2SUB FUNC EXPORT

```

FETCHY2    (a0)+,d0,d1,d2,d3      ; add Ya to RGB values
FETCHY2    (a1)+,d0,d4,d5,d6      ; add Yb to RGB values
rts

```

ENDFUNC

if \$TYPE('seg')='UNDEFINED' then

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Engineering: KlicsCode: CompPict: Color2.a

```

seg      6seg
endit

YUV2RGB5  FUNC  EXPORT
.
PS        RECORD      3
Table     DS.L        1
pixmap    DS.L        1
Y         DS.L        1
U         DS.L        1
V         DS.L        1
area      DS.L        1
width     DS.L        1
cols      DS.L        1
        ENDR
.
LS        RECORD      0,DECR
inc       DS.L        1
width     DS.L        1
fend      DS.L        1
count     DS.L        1
row       DS.L        1
LSize     EQU         -
        ENDR
.
.      a0 - Y0, a1 - Y1, a2 - U, a3 - V, a4 - pm0, a5 - pm1
.      d0..6 - used, d7 - count
.
link      a6,*LS.LSize      ; inc. width, fend and rowend are loca
movem.l   d4-d7/a3-a5,-(a7) ; store registers
.
move.l    PS.pixmap(a6),a4   ; pm0=pixmap
move.l    a4,a5              ; pm1=pm0
move.l    PS.Y(a6),a0        ; Y0=Yc
move.l    a0,a1              ; Y1=Y0
move.l    PS.U(a6),a2        ; U=Uc
move.l    PS.V(a6),a3        ; V=Vc
move.l    PS.area(a6),d7     ; fend=area
lsl.l     #2,d7              ; fend<=2
add.l     a4,d7              ; fend+=pm0
move.l    d7,LS.fend(a6)     ; save fend
move.l    PS.width(a6),d5    ; width=width
move.l    d5,d7              ; count=width
asr.l     #1,d7              ; count>=1
subq.l    #1,d7              ; count-=1
move.l    d7,PS.width(a6)    ; save width

add.l     d5,d5              ; width*=2
add.l     d5,a1              ; Y1+=width
add.l     d5,d5              ; width*=2
move.l    d5,LS.width(a6)    ; save width
move.l    PS.cols(a6),d4     ; inc=cols
lsl.l     #2,d4              ; inc<=2
move.l    d4,LS.row(a6)      ; *NEW save row
add.l     d4,a5              ; pm1+=inc
add.l     d4,a5              ; *NEW pm1+=inc
add.l     d4,d4              ; cols*=2
add.l     d4,d4              ; *NEW cols*=2
sub.l     d5,d4              ; inc now 4*cols-width bytes
sub.l     d5,d4              ; *NEW inc now 4*cols-width bytes (wid
move.l    d4,LS.inc(a6)      ; save inc

9d:      move.l    d7,-(sp)

```

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Engineering:KilicsCode:CompPict:Color2.a

```

move.l    a6,-(sp)
move.l    LS.row(a6),d7
move.l    PS.Table(a6),a6
UV2RGB4    (a2)+,(a3)+          ; uv2rgb(*U+*,*V+*)

FETCHY2    (a0)+,d0,d1,d2,d3      ; add Ya to RGB values
FETCHY2    (a1)+,d0,d4,d5,d6      ; add Yb to RGB values

move.l    d1,d0
or.l      d2,d0
or.l      d3,d0
or.l      d4,d0
or.l      d5,d0
or.l      d6,d0
andi.l    *$FF00FF00,d0
bne.w     @over          ; if overflow

@ok        MKRGB2    d1,d2,d3,a4,d7,d0 ; *NEW save RGBa
           MKRGB2    d4,d5,d6,a5,d7,d0 ; *NEW save RGBb
           move.l    (sp)+,a6
           move.l    (sp)+,d7

           dbf        d7,@do          ; while

           adda.l     LS.inc(a6),a4      ; pm0+=inc
           adda.l     LS.inc(a6),a5      ; pm1+=inc
           adda.l     LS.width(a6),a0    ; Y0+=width
           exg.l      a0,a1              ; Y1<->Y0
           move.l     PS.width(a6),d7    ; count=width
           cmpa.l     LS.fend(a6),a4     ; pm0<fend
           blt.s      @do                ; while

           movem.l    (a7)+,d4-d7/a3-a5 ; restore registers
           unlk       a6                ; remove locals
           rts         ; return

@over      move.l     d7,LS.count(a6)    ; save count
           clr.w      d7                ; AND=0
           FIXOV      d1,d0,d7          ; A overflow
           FIXOV      d2,d0,d7          ; B overflow
           FIXOV      d3,d0,d7          ; A overflow
           FIXOV      d4,d0,d7          ; B overflow
           FIXOV      d5,d0,d7          ; A overflow
           FIXOV      d6,d0,d7          ; B overflow
           move.l     LS.count(a6),d7    ; restore count
           bra        @ok

           ENDFUNC
           -----
           END

```

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Engineering:KLICSCode:CompFast:Clut.c

```

.....
* Copyright 1993 KLICS Limited
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*
* Written by: Adrian Lewis
*
.....
/*
Analyse CLUT setup and pick appropriate
YUV->RGB converter/display driver. Create
any tables necessary.
*/

#include <QuickDraw.h>
#include <Memory.h>

#define Y_LEVELS    64
#define UV_LEVELS   16

#define absv(v) ((v)<0?-(v):(v))
#define NewPointer(ptr,type,size) \
    saveZone=GetZone(); \
    SetZone(SystemZone()); \
    if (nil==(ptr)=(type)NewPtr(size)) { \
        SetZone(ApplicZone()); \
        if (nil==(ptr)=(type)NewPtr(size)) { \
            SetZone(saveZone); \
            return(MemoryError()); \
        } \
    } \
    SetZone(saveZone);

typedef struct {
    char    y, u, v;
} YUV_Clut;

/*
unsigned char *
ColourClut(CTabHandle clut)
{
    int    size, y, u, v, r, g, b, i;
    unsigned char *table;
    YUV_Clut    *yuv_clut;

    size=(*clut)->ctSize;
    table=(unsigned char *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS);
    yuv_clut=(YUV_Clut *)NewPtr(size*sizeof(YUV_Clut));

    for(i=0;i<size;i++) {
        r=((*clut)->ctTable[i].rgb.red>>8)-128;
        g=((*clut)->ctTable[i].rgb.green>>8)-128;
        b=((*clut)->ctTable[i].rgb.blue>>8)-128;

        yuv_clut[i].y= (306*r + 601*g + 117*b)>>10;
        yuv_clut[i].u= (512*r - 429*g - 83*b)>>10;
        yuv_clut[i].v= (-173*r - 339*g + 512*b)>>10;
    }
    for(y=-Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
    for(u=-UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
    for(v=-UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
        int    index,error,error2,points, Y, U, V;

```

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Engineering:KlicsCode:CompPict:Clut.c

```

Y=y<<4;
U=u<<3;
V=v<<5;

index=0;
error=131072;
error2=131072;
points=0;
for(i=0;i<=size;i++) {
    int pts=0, err=0;

    if (yuv_clut[i].y>=Y && yuv_clut[i].y<Y+16)
        pts+=1;
    err+=absv(yuv_clut[i].y-Y);

    if (yuv_clut[i].u>=U && yuv_clut[i].u<U+32)
        pts+=1;
    err+=absv(yuv_clut[i].u-U);

    if (yuv_clut[i].v>=V && yuv_clut[i].v<V+32)
        pts+=1;
    err+=absv(yuv_clut[i].v-V);

    if (pts>points || (pts==points && err<error)) {
        error=err;
        index=i;
        points=pts;
    }
}
i=((y&0x1F)<<8)|((u&0xF)<<4)|(v&0xF);
table[i]=(unsigned char)index;
}
DisposePtr((Ptr)yuv_clut);
return table;
}

typedef union {
    long    pixel;
    unsigned char    rgb[4];
} Pixel;
/*
unsigned long *
ColourClut(CTabHandle clut)
{
    long    size, y, u, v, r, g, b, ro, go, bo, i;
    Pixel    *table;

    size=(clut->ctSize;
    table=(Pixel *)NewPtr(Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long));

    for(y=-Y_LEVELS/2;y<Y_LEVELS/2-1;y++)
    for(u=-UV_LEVELS/2;u<UV_LEVELS/2-1;u++)
    for(v=-UV_LEVELS/2;v<UV_LEVELS/2-1;v++) {
        Pixel    px;
        long    base, dith;

        r = 32768L + ((y<<9) + 1436L*u <<2);
        g = 32768L + ((y<<9) - 731L*u - 352L*v <<2);
        b = 32768L + ((y<<9) + 1815L*v <<2);

        r=r<0?0:r>65534?65534:r;
        g=g<0?0:g>65534?65534:g;
        b=b<0?0:b>65534?65534:b;
    }
}

```

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Engineering:KlicsCode:CompPict:Clut.c

```

ro=r%13107; r=r/13107;
go=g%13107; g=g/13107;
bo=b%13107; b=b/13107;

base=215-(35*r-6*g-b);

dith=base-(ro>2621736:0)-(go>786376:0)-(bo>1048471:0);
px.rgb[0]=dith==215?255:dith;

dith=base-(ro>5242736:0)-(go>1048476:0)-(bo>262171:0);
px.rgb[1]=dith==215?255:dith;

dith=base-(ro>7863736:0)-(go>262176:0)-(bo>524271:0);
px.rgb[2]=dith==215?255:dith;

dith=base-(ro>10484736:0)-(go>524276:0)-(bo>786371:0);
px.rgb[3]=dith==215?255:dith;

i=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

table[i].pixel=px.pixel;
}
return (unsigned long*)table;
}

typedef struct {
    long    red, green, blue;
} RGBError;

OSErr ColourClut(Pixel **table)
{
    long    y, u, v, r, g, b, i;
    RGBError *err;
    THz     saveZone;

    NewPointer(*table, Pixel*.Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(long)); /* 64k ta
    NewPointer(err, RGBError*, Y_LEVELS*UV_LEVELS*UV_LEVELS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-Y_LEVELS/2; y<Y_LEVELS/2; y++)
            for(u=-UV_LEVELS/2; u<UV_LEVELS/2; u++)
                for(v=-UV_LEVELS/2; v<UV_LEVELS/2; v++) {
                    RGBColor    src, dst;
                    long        index, in;

                    index=((y&0x3F)<<8)|((u&0xF)<<4)|(v&0xF);

                    r = 32768L + ((y<<9) + (1436L*u) <<2);
                    g = 32768L + ((y<<9) - (731L*u) - (352L*v) <<2);
                    b = 32768L + ((y<<9) + (1815L*v) <<2);

                    if (i>0) {
                        r-=err[index].red;
                        g-=err[index].green;
                        b-=err[index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[index].rgb[i]=(unsigned char)Color2Index(&src);
                }
            }
        }
    }

```


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➤ Engineering:KlitsCode:CompPict:Clut.c

```

Index2Color((*table)[index].rgb[i], &dst);
err[index].red=dst.red-src.red;
err[index].green=dst.green-src.green;
err[index].blue=dst.blue-src.blue;
}
DisposePtr((Ptr)err);
return(noErr);
}

typedef struct (
    short    pel[2];
) Pix16;

typedef struct (
    unsigned char    pel[4];
) Pix8;

#define YS 64
#define UVS 12

OSErr Colour8(Pix8 **table)
(
    long    y, u, v, r, g, b, i;
    RGBError    *err;
    THz    saveZone;

    NewPointer(*table, Pix8*, YS*UVS*UVS*sizeof(Pix8)); /* 128k table */
    NewPointer(err, RGBError*, YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<4; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor    src, dst;
                    long    index;

                    index=(y<<10)|((u<0x1F)<<5)|((v<0x1F)<<1);

                    r = 32768L + ((y<<10) + (1436L*u) <<1);
                    g = 32768L + ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L + ((y<<10) + (1815L*v) <<1);

                    if (i>0) {
                        r-=err[32768+index].red;
                        g-=err[32768+index].green;
                        b-=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    (*table)[32768+index].pel[i]=(unsigned char)Color2Index(&src);
                    Index2Color((*table)[32768+index].pel[i], &dst);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

```

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Engineering:KlidesCode:CompPict:Clut.c

```

OSErr Colour16(Pix16 **table)
{
    long    y, u, v, r, g, b;
    RGBError *err;
    THz     saveZone;

    NewPointer((**table, Pix16*, YS*UVS*UVS*sizeof(Pix16)); /* 128k table */
    NewPointer(err, RGBError*, YS*UVS*UVS*sizeof(RGBError));

    for(i=0; i<2; i++)
        for(y=-YS/2; y<YS/2; y++)
            for(u=-UVS/2; u<UVS/2; u++)
                for(v=-UVS/2; v<UVS/2; v++) {
                    RGBColor src, dst;
                    long index;

                    index=(y<<10)|((u&0x1F)<<5)|(v&0x1F);

                    r = 32768L - ((y<<10) + (1436L*u) <<1);
                    g = 32768L - ((y<<10) - (731L*u) - (352L*v) <<1);
                    b = 32768L - ((y<<10) + (1815L*v) <<1);

                    if (i>0) {
                        r-=err[32768+index].red;
                        g-=err[32768+index].green;
                        b-=err[32768+index].blue;
                    }

                    src.red=r<0?0:r>65534?65534:r;
                    src.green=g<0?0:g>65534?65534:g;
                    src.blue=b<0?0:b>65534?65534:b;

                    dst.red= src.red&0xF800;
                    dst.green= src.green&0xF800;
                    dst.blue= src.blue&0xF800;

                    (*table)[32768+index].pel[i]=(dst.red>>1)|(dst.green>>6)|(dst.blue>>11);

                    err[32768+index].red=dst.red-src.red;
                    err[32768+index].green=dst.green-src.green;
                    err[32768+index].blue=dst.blue-src.blue;
                }
    DisposePtr((Ptr)err);
    return(noErr);
}

Boolean
GreyClut(CTabHandle clut)
{
    Boolean result=true;
    int i, size;

    size=(*clut)->ctSize;
    for(i=0; i<=size && result; i++) {
        int r,g,b;

        r=(*clut)->ctTable[i].rgb.red;
        g=(*clut)->ctTable[i].rgb.green;
        b=(*clut)->ctTable[i].rgb.blue;

        result=(r==g && g==b);
    }
}

```

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➤ Engineering:KlicsCode:CompPic:Clut.c

return result;

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Engineering:KlicsCode:CompPict:Bits3.h

```

.....
* Copyright 1993 KLICS Limited
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*
* Written by: Adrian Lewis
*
...../
/*
Bits3.h: fast bit read/write definitions

buf_use      define static variables
buf_winit    initialise vars for write
buf_rinit    initialise vars for read
buf_set      set current bit
buf_get      get current bit
buf_winc     increment write buffer
buf_rinc     increment read buffer
buf_size     fullness of buffer in bytes
buf_flush    flush buffer

User defined macro/function buf_over must be defined in case of buffer overflow
*/

typedef struct (
    unsigned long    *buf;
    union (
        unsigned long    mask;
        long    bno;
    ) index;
    unsigned long    *ptr, data, size;
) Buffer, *Buf;

#define buf_winit(buf) \
    buf->index.mask=0x80000000; \
    buf->ptr=&buf->buf[0]; \
    buf->data=0;

#define buf_rinit(buf) \
    buf->index.bno=0; \
    buf->ptr=&buf->buf[0];

#define buf_set(buf) \
    buf->data |= buf->index.mask;

#define buf_get(buf) \
    0!==(buf->data & (1<<buf->index.bno) )

#define buf_winc(buf) \
    if (buf->index.mask==1) { \
        *buf->ptr=buf->data; \
        buf->data=0; \
        buf->index.mask=0x80000000; \
        buf->ptr++; \
    } else buf->index.mask >>= 1;

#define buf_rinc(buf) \
    if (--(buf->index.bno)<0) { \
        buf->data=*buf->ptr++; \
        buf->index.bno=31; \
    };

/* buf_size only valid after buf_flush */

```

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Engineering:KlicsCode:CompPict:Bits3.h

```
*define buf_size(buf) \
(unsigned char *)buf->ptr-(unsigned char *)&buf->buf[0]

*define buf_flush(buf) \
if (buf->index.mask!=0x80000000) { \
    buf->data|=buf->index.mask-1; \
    *buf->ptr=buf->data; \
    buf->ptr++; \
}
```

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Engineering:KLICSCode:CompPict:Bits3.a

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Written by: Adrian Lewis

63000 Bit buffer code (Bits2.h)

Macros:

```
buf_winit    &ptr, &data, &mask, &buf
buf_rinit    &ptr, &bno, &buf
buf_set      &data, &mask
buf_get      &data, &bno
buf_winc     &ptr, &data, &mask
buf_rinc     &ptr, &data, &index
buf_flush    &ptr, &data, &mask
```

```
macro
buf_winit    &ptr, &data, &mask, &buf

move.l      #$80000000, &mask      ; mask=100...
move.l      &buf, &ptr             ; ptr=buf
clr.l       &data                  ; data=0

endm
```

```
macro
buf_rinit    &ptr, &bno, &buf

clr.b       &bno                  ; bno=0
move.l      &buf, &ptr            ; ptr=buf

endm
```

```
macro
buf_set      &data, &mask

or.l        &mask, &data          ; data |= mask

endm
```

```
macro
buf_get      &data, &bno

subq.b      #1, &bno
btsr        &bno, &data

endm
```

```
macro
buf_winc     &ptr, &data, &mask

lsr.l       #1, &mask              ; mask>>=1
bne.s       @cont                 ; if non-zero continue
move.l      &data, (&ptr)+        ; *ptr++=data
clr.l       &data                 ; data=0
move.l      #$80000000, &mask     ; mask=100...
```

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Engineering:KlicsCode:CompPict:Bits}.a

10000

endm

```
macro
buf_inc      iptr,&data,&bno
```

cmpl.b #16.&bno

bge.s @cont

swap &data

```

swap      move.w      (%eax), %eax
move.w    (%eax), %eax

```

```

move.w      (a0),d0
add.b       #16,d0

```

```
; data="ptr++"
; bno+=16
```

@cont

endm

```
macro
buf_flush    &ptr,&data,&mask
```

CH0.1 #580000000, &mask

beg. s 3 cont

```

move.l    &data, (&ptr)+

```

```
; mask-8000000?
; if buffer empty continue
; *ptr++=data
```

endm

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Engineering:KlicsCode:CompPict:Backward.c

```

.....
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*  Written by: Adrian Lewis
...../

```

```

Extra fast Backward\convolver
New wavelet coeffs : 3 5 1 1, 1 2 1, 1 1

```

```

Optimized for speed:
  dirn = False
  src/dst octave == 0
*/

```

```

#define BwdS0(addr0,dAG,dAH,dBH) \
  v=(short *)addr0; \
  dAG=-v; \
  dAH=v; \
  dBH=v<<1; \

#define BwdS1(addr1,addr0,dAG,dAH,dBH) \
  v=(short *)addr1; \
  dBH+= v>>1; \
  dAG+= v-(vs=v<<1); \
  dAH+= v-(vs<=1); \
  *(short *)addr0=dBH>>1; \

#define Bwd2(addr2,dAG,dAH,dBG,dBH) \
  v=(short *)addr2; \
  dBG=-v; \
  dBH=v; \
  dAH+= v-(vs=v<<1); \
  dAG+= v-(vs<=1); \

#define Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
  v=(short *)addr3; \
  dAH+= v; \
  dAG+= v; \
  dBG+= v-(vs=v<<1); \
  dBH+= v-(vs<=1); \
  *(short *)addr1=(dAH-1)>>2; \
  *(short *)addr2=(dAG-1)>>2; \

#define Bwd0(addr0,dAG,dAH,dBG,dBH) \
  v=(short *)addr0; \
  dAG=-v; \
  dAH=v; \
  dBH+= v-(vs=v<<1); \
  dBG+= v-(vs<=1); \

#define Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
  v=(short *)addr1; \
  dBH+= v; \
  dBG+= v; \
  dAG+= v-(vs=v<<1); \
  dAH+= v-(vs<=1); \
  *(short *)addr3=(dBH-1)>>2; \
  *(short *)addr0=(dBG-1)>>2; \

#define BwdE2(addr2,dAG,dAH,dBH) \

```


Engineering:KilicsCode:CompPict:Backward.c

```

v=*(short *)addr2; \
dBH= vs=v<<1; \
dAH= v-(vs=v<<1); \
dAG= v-(vs<<=1);

#define BwdE3(addr3,addr2,addr1,dAG,dAH,dBH) \
v=*(short *)addr3; \
dAH+= v; \
dAG+= v; \
dBH= v+(vs=v<<1); \
dBH= v+(vs<<=1); \
*(short *)addr1=(dAH+1)>>2; \
*(short *)addr2=(dAG+1)>>2; \
*(short *)addr3=dBH>>1;

#define Bwd(base,end,inc) \
addr0=base; \
addr3=addr0-(inc>>2); \
addr2=addr3-(inc>>2); \
addr1=addr2-(inc>>2); \
BwdS0(addr0,dAG,dAH,dBH); \
addr1+=inc; \
BwdS1(addr1,addr0,dAG,dAH,dBH); \
addr2+=inc; \
while(addr2<end) { \
    Bwd2(addr2,dAG,dAH,dBG,dBH); \
    addr3+=inc; \
    Bwd3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0(addr0,dAG,dAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2(addr2,dAG,dAH,dBH); \
addr3+=inc; \
BwdE3(addr3,addr2,addr1,dAG,dAH,dBH);

#define BwdS0r2(addr0,dAG,dAH,dBH) \
v=*(short *)addr0; \
dAG= 0; \
dAH= v; \
dBH= v; \

#define BwdS1r2(addr1,addr0,dAG,dAH,dBH) \
v=*(short *)addr1; \
dBH+= v>>2; \
dAG+= v; \
dAH+= v<<1; \
*(short *)addr0=dBH;

#define Bwd2r2(addr2,dAG,dAH,dBG,dBH) \
v=*(short *)addr2; \
dBG= 0; \
dBH= v; \
dAH+= v; \
dAG+= v<<1;

#define Bwd3r2(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
v=*(short *)addr3; \
dAH+= 0; \
dAG+= v; \
dBG+= v; \

```

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Engineering:KillsCode:CompFicc:Backward.c

```

    dBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1;

#define Bwd0r2(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= v; \
    dBH-= v; \
    dBG-= v<<1;

#define Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH-= 0; \
    dBG-= v; \
    dAG+= v; \
    dAH-= v<<1; \
    *(short *)addr3=dBH>>1; \
    *(short *)addr0=dBG>>1;

#define BwdE2r2(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    dBH= v; \
    dAH+= v; \
    dAG+= v<<1;

#define BwdE3r2(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= v; \
    dBH-= v; \
    dBH-= v<<1; \
    *(short *)addr1=dAH>>1; \
    *(short *)addr2=dAG>>1; \
    *(short *)addr3=dBH;

#define Bwdr2(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0r2(addr0,dAG,dAH,dBH); \
    addr1+=inc; \
    BwdS1r2(addr1,addr0,dAG,dAH,dBH); \
    addr2+=inc; \
    while(addr2<end) { \
        Bwd2r2(addr2,dAG,dAH,dBG,dBH); \
        addr+=inc; \
        Bwd3r2(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
        addr0+=inc; \
        Bwd0r2(addr0,dAG,dAH,dBG,dBH); \
        addr1+=inc; \
        Bwd1r2(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
        addr2+=inc; \
    } \
    BwdE2r2(addr2,dAG,dAH,dBH); \
    addr+=inc; \
    BwdE3r2(addr3,addr2,addr1,dAG,dAH,dBH);

#define BwdS0r3(addr0,dAG,dAH,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= 0; \

```

Engineering:KlicsCode:CompPict:Backward.c

```

    dBH= v>>1; \

#define BwdS1r3(addr1,addr0,dAG,dAH,dBH) \
    v=(short *)addr1; \
    dBH= v>>1; \
    dAG+= v; \
    dAH+= v; \
    *(short *)addr0=dBH<<1;

#define Bwd2r3(addr2,dAG,dAH,dBG,dBH) \
    v=(short *)addr2; \
    dBG= 0; \
    dBH= 0; \
    dAH+= v; \
    dAG+= v;

#define Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBG+= v; \
    dBH+= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG;

#define Bwd0r3(addr0,dAG,dAH,dBG,dBH) \
    v=(short *)addr0; \
    dAG= 0; \
    dAH= 0; \
    dBH+= v; \
    dBG+= v;

#define Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH) \
    v=(short *)addr1; \
    dBH+= 0; \
    dBG+= 0; \
    dAG+= v; \
    dAH+= v; \
    *(short *)addr3=dBH; \
    *(short *)addr0=dBG;

#define BwdE2r3(addr2,dAG,dAH,dBH) \
    v=(short *)addr2; \
    dBH= v>>1; \
    dAH+= v; \
    dAG+= v;

#define BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH) \
    v=(short *)addr3; \
    dAH+= 0; \
    dAG+= 0; \
    dBH+= v; \
    dBH+= v; \
    *(short *)addr1=dAH; \
    *(short *)addr2=dAG; \
    *(short *)addr3=dBH<<1;

#define Bwdr3(base,end,inc) \
    addr0=base; \
    addr3=addr0-(inc>>2); \
    addr2=addr3-(inc>>2); \
    addr1=addr2-(inc>>2); \
    BwdS0r3(addr0,dAG,dAH,dBH); \

```

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Engineering:KlicsCode:CompPict:Backward.c

```

addr1+=inc; \
BwdS1r3(addr1,addr0,dAG,dAH,dBH); \
addr2+=inc; \
while(addr2<end) { \
    Bwd2r3(addr2,dAG,dAH,dBG,dBH); \
    addr3+=inc; \
    Bwd3r3(addr3,addr2,addr1,dAG,dAH,dBG,dBH); \
    addr0+=inc; \
    Bwd0r3(addr0,dAG,dAH,dBG,dBH); \
    addr1+=inc; \
    Bwd1r3(addr1,addr0,addr3,dAG,dAH,dBG,dBH); \
    addr2+=inc; \
} \
BwdE2r3(addr2,dAG,dAH,dBH); \
addr3+=inc; \
BwdE3r3(addr3,addr2,addr1,dAG,dAH,dBH);

extern void FASTBACKWARD(char *data, long incl, long loop1, long inc2, char *end2)
extern void HAARBACKWARD(char *data, long incl, long loop1, long inc2, long loop2)
extern void HAARTOPBWD(char *data, long height, long width);
/* extern void HAARXTOPBWD(char *data, long area); */

void FasterBackward(char *data, long incl, long endl, long inc2, char *end2)
{
    register short v, vs, v3, dAG, dAH, DBG, dBH, inc;
    register char *addr0, *addr1, *addr2, *addr3, *end;
    char *base;

    inc=incl;
    for(base=data; base<end2; base+=inc2) {
        end=base+endl;
        Bwd(base, end, inc);
    }
}

extern void TOPBWD(char *data, char *dst, long size_1, long size_0);

void TestTopBackward(short *data, int size[2], int oct_src)
{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1; oct>0; oct--) {
        long cinc=2<<oct, cinc4=cinc<<2;
        rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in t

        FASTBACKWARD((char *)data, rinc4, area-(rinc<<1), cinc, left);
        FASTBACKWARD((char *)data, cinc4, width-(cinc<<1), rinc, top);
    }
    /* FasterBackward((char *)data, size[0]<<3, area-(size[0]<<2), 2, left);
    FasterBackward((char *)data, 8, width-4, size[0]<<1, top); */
    TOPBWD((char *)data, (char *)data, size[0], size[1]);
}

void TestBackward(data, size, oct_src)
short *data;
int size[2], oct_src;

{
    int oct, area=size[0]*size[1]<<1;
    short width=size[0]<<1;
    char *top=area+(char *)data, *left=width+(char *)data;

```

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Engineering:KlidsCode:CompPict:Backward.c

```

for(oct=oct_src-1;oct>=0;oct--) {
    long    cinc=2<<oct, cinc4=cinc<<2,
            rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

    FasterBackward((char *)data,rinc4,area-(rinc<<1),cinc,left);
    FasterBackward((char *)data,cinc4,width-(cinc<<1),rinc,top);
}

void    Backward3511(data,size,oct_src)
short    *data;
int    size[2], oct_src;
{
    int    oct, area=size[0]*size[1]<<1;
    short    width=size[0]<<1;
    char    *top=area+(char *)data, *left=width+(char *)data;

    for(oct=oct_src-1;oct>0;oct--) {
        long    cinc=2<<oct, cinc4=cinc<<2,
                rinc=size[0]<<oct+1, rinc4=rinc<<2; /* col and row increments in c

        BACK3511((char *)data,rinc4,area-(rinc<<1),cinc,left);
        BACK3511((char *)data,cinc4,width-(cinc<<1),rinc,top);
    }
    BACK3511V((char *)data,size[0]<<3,area-(size[0]<<2),4,left);
    BACK3511H((char *)data,8,width-4,size[0]<<1,top);
    /* TOPBWD((char *)data,(char *)data,size[1],size[0]); */
}

```

Engineering: KlicsCode: CompPict: Backward.a

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Written by: Adrian Lewis

680X0 1511 Backward code

Coeffs 11 19 5 3
become 3 5 1 1

seg 'klics'

```
macro
BwdStart0    &addr0, &dAG, &dAH, &dBH

move.w       (&addr0), &dAH    ; dAH = *(short *)addr0
move.w       &dAH, &dAG        ; dAG = v
neg.w        &dAG              ; dAG = -dAG
move.w       &dAH, &dBH        ; dBH = v
add.w        &dBH, &dBH        ; dBH = v << 1
```

endm

```
macro
BwdStart1    &addr1, &addr0, &dAG, &dAH, &dBH

move.w       (&addr1), d0      ; v = *(short *)addr1
move.w       d0, d1            ; v = v
asr.w        #1, d1            ; v = v >> 1
add.w        d1, &dBH          ; dBH = v >> 1
add.w        d0, &dAG          ; dAG = v
sub.w        d0, &dAH          ; dAH = v
add.w        d0, d0            ; v << 1
add.w        d0, &dAG          ; dAG = 2v
add.w        d0, d0            ; v << 1
sub.w        d0, &dAH          ; dAH = 4v
asr.w        #1, &dBH          ; dBH >> 1
move.w       &dBH, (&addr0)    ; *(short *)addr0 = dBH
```

endm

```
macro
BwdEven      &addr2, &dAG, &dAH, &DBG, &dBH
```

```
move.w       (&addr2), d0      ; v = *(short *)addr2
move.w       d0, &dBH          ; dBH = v
move.w       d0, &DBG          ; DBG = v
neg.w        &DBG              ; DBG = -v
add.w        d0, &dAH          ; dAH = v
add.w        d0, &dAG          ; dAG = v
add.w        d0, d0            ; 2v
add.w        d0, &dAH          ; dAH = v
add.w        d0, d0            ; 2v
add.w        d0, &dAG          ; dAH = v
```

endm

macro

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Engineering: KlicsCode: CompPict: Backward.a

```

BwdOdd      &addr3, &addr2, &addr1, &dAG, &dAH, &DBG, &dBH
move.w      (&addr3), d0      ; v = (short *)addr3
add.w       d0, &dAH          ; dAH += v
add.w       d0, &dAG          ; dAG += v
add.w       d0, &DBG          ; DBG += v
sub.w       d0, &dBH          ; dBH -= v
add.w       d0, d0            ; 2v
add.w       d0, &DBG          ; DBG += v
add.w       d0, d0            ; 4v
sub.w       d0, &dBH          ; dBH -= 4v

asr.w       #2, &dAH          ; dAH >>= 2
move.w      &dAH, (&addr1)    ; *(short *)addr1 = dAH
asr.w       #2, &dAG          ; dAG >>= 2
move.w      &dAG, (&addr2)    ; *(short *)addr2 = dAG

endm

```

```

macro
BwdEnd2      &addr2, &dAG, &dAH, &dBH

move.w      (&addr2), d0      ; v = (short *)addr2
add.w       d0, &dAH          ; dAH += v
add.w       d0, &dAG          ; dAG += v
add.w       d0, d0            ; 2v
move.w      d0, &dBH          ; dBH = 2v
add.w       d0, &dAH          ; dAH += 2v
add.w       d0, d0            ; 4v
add.w       d0, &dAG          ; dAG += 4v

endm

```

```

macro
BwdEnd3      &addr3, &addr2, &addr1, &dAG, &dAH, &dBH

move.w      (&addr3), d0      ; v = (short *)addr3
add.w       d0, &dAH          ; dAH += v
add.w       d0, &dAG          ; dAG += v
lsl.w       #3, d0            ; 8v
sub.w       d0, &dBH          ; dBH -= 8v
asr.w       #2, &dAH          ; dAH >>= 2
move.w      &dAH, (&addr1)    ; *(short *)addr1 = dAH
asr.w       #2, &dAG          ; dAG >>= 2
move.w      &dAG, (&addr2)    ; *(short *)addr2 = dAG
asr.w       #1, &dBH          ; dBH >>= 1
move.w      &dBH, (&addr3)    ; *(short *)addr3 = dBH

endm

```

```

macro
Bwd          &base, &end, &inc

movea.l     &base, a0          ; addr0 = base
move.l      &inc, d0           ; d0 = inc
asr.l       #2, d0             ; d0 = inc >> 2
movea.l     a0, a3             ; addr3 = addr0
suba.l      d0, a3             ; addr3 -= (inc >> 2)
movea.l     a3, a2             ; addr2 = addr3
suba.l      d0, a2             ; addr2 -= (inc >> 2)
movea.l     a2, a1             ; addr1 = addr2

```

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Engineering:KlicsCode:CompPict:Backward.a

```

suba.l    d0,a1                ; addr1+=(inc>>2)
BwdStart0 a0,d4,d5,d7         ; BwdStart0(addr0,dAG,dAH,dBH)
adda.l    &inc,a1              ; addr1+=inc
BwdStart1 a1,a0,d4,d5,d7      ; BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l    &inc,a2              ; addr2+=inc
?do       BwdEven             ; BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l    &inc,a3              ; addr3+=inc
BwdOdd    a3,a2,a1,d4,d5,d6,d7 ; BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l    &inc,a0              ; addr0+=inc
BwdEven   a0,d6,d7,d4,d5       ; BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l    &inc,a1              ; addr1+=inc
BwdOdd    a1,a0,a3,d6,d7,d4,d5 ; BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l    &inc,a2              ; addr2+=inc
cmpa.l    a2,&end              ; addr2<end
bgt.s     @do                  ; while
BwdEnd2   a2,d4,d5,d7         ; BwdEnd2(addr2,dAG,dAH,dBH)
adda.l    &inc,a3              ; addr3+=inc
BwdEnd3   a3,a2,a1,d4,d5,d7   ; BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB

```

endm

Back3511 FUNC EXPORT

```

PS        RECORD      8
data      DS.L         1
inc1      DS.L         1
end1      DS.L         1
inc2      DS.L         1
end2      DS.L         1
ENDR

```

```

link      a6,#0          ; no local variables
movem.l   d4-d7/a3-a5,-(a7) ; store registers

move.l    PS.inc1(a6),d3   ; inc=inc1
movea.l   PS.data(a6),a5   ; base=data
movea.l   a5,a4            ; end=base
adda.l    PS.end1(a6),a4   ; end+=end1
Bwd       a5,a4,d3         ; Bwd(base,end,inc)
adda.l    PS.inc2(a6),a5   ; base+=inc2
cmpa.l    PS.end2(a6),a5   ; end2>base
blt.w     @do              ; for

movem.l   (a7)+,d4-d7/a3-a5 ; restore registers
unlk      a6               ; remove locals
rts       ; return

```

ENDFUNC

```

macro
BwdStartV0 &addr0,&dAG,&dAH,&dBH

move.l    (&addr0),&dAH    ; dAH=(short *)addr0
move.l    &dAH,&dAG         ; dAG=v
neg.l     &dAG              ; dAG=-dAG
move.l    &dAH,&dBH         ; dBH=v
add.l     &dBH,&dBH         ; dBH=v<<1

```

endm

```

macro
BwdStartV1 &addr1,&addr0,&dAG,&dAH,&dBH

```


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=Engineering:Kl:csCode:CompPict:Backward.a

```

move.l    (&addr1).d0    ; v=(short *)addr1
move.l    d0,d1          ; vs=v
asr.l     #1,d1          ; vs=v>>1
add.l     d1,&dbH        ; dbH+=v>>1
add.l     d0,&dAG        ; dAG+=v
sub.l     d0,&dAH        ; dAH-=v
add.l     d0,d0          ; v<<=1
add.l     d0,&dAG        ; dAG+=2v
add.l     d0,d0          ; v<<=1
sub.l     d0,&dAH        ; dAH-=4v

asr.l     #1,&dbH        ; dbH>>=1
add.w     &dbH,&dbH      ; shift word back
asr.w     #1,&dbH        ; dbH>>=1
move.l    &dbH,(&addr0) ; *(short *)addr0=dbH

```

endm

```

macro
BwdEvenV    &addr2,&dAG,&dAH,&dbG,&dbH

```

```

move.l    (&addr2).d0    ; v=(short *)addr2
move.l    d0,&dbH        ; dbH=v
move.l    d0,&dbG        ; dbG=v
neg.l     &dbG            ; dbG=-v
add.l     d0,&dAH        ; dAH+=v
add.l     d0,&dAG        ; dAG+=v
add.l     d0,d0          ; 2v
add.l     d0,&dAH        ; dAH+=2v
add.l     d0,d0          ; 2v
add.l     d0,&dAG        ; dAH+=v

```

endm

```

macro
BwdOddV     &addr3,&addr2,&addr1,&dAG,&dAH,&dbG,&dbH

```

```

move.l    (&addr3).d0    ; v=(short *)addr3

add.l     d0,&dAH        ; dAH+=v
add.l     d0,&dAG        ; dAG+=v
add.l     d0,&dbG        ; dbG+=v
sub.l     d0,&dbH        ; dbH-=v
add.l     d0,d0          ; 2v
add.l     d0,&dbG        ; dbG+=v
add.l     d0,d0          ; 4v
sub.l     d0,&dbH        ; dbH-=4v

asr.l     #2,&dAH        ; dAH>>=2
lsl.w     #2,&dAH        ; shift word back
asr.w     #2,&dAH        ; dAH>>=2
move.l    &dAH,(&addr1) ; *(short *)addr1=dAH
asr.l     #2,&dAG        ; dAG>>=2
lsl.w     #2,&dAG        ; shift word back
asr.w     #2,&dAG        ; dAG>>=2
move.l    &dAG,(&addr2) ; *(short *)addr2=dAG

```

endm

```

macro
BwdEndV2    &addr2,&dAG,&dAH,&dbH

```

```

move.l    (&addr2).d0    ; v=(short *)addr2

```

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Engineering:KlincsCode:CompPict:Backward.a

```

add.l    d0,&dAH      : dAH+=v
add.l    d0,&dAG      : dAG+=v
add.l    d0,d0        : 2v
move.l   d0,&dBH      : dBH=2v
add.l    d0,&dAH      : dAH+=2v
add.l    d0,d0        : 4v
add.l    d0,&dAG      : dAG+=4v

```

endm

```

-----
macro
BwdEndV3    &addr1,&addr2,&addr1,&dAG,&dAH,&dBH

move.l     (&addr3),d0      : v=(short *)addr3
add.l      d0,&dAH          : dAH+=v
add.l      d0,&dAG          : dAG+=v
lsl.l      #3,d0            : 8v
sub.l      d0,&dBH          : dBH-=8v
asr.l      #2,&dAH          : dAH>>=2
lsl.w      #2,&dAH          : shift word back
asr.w      #2,&dAH          : dAH>>=2
move.l     &dAH,(&addr1)    : *(short *)addr1=dAH
asr.l      #2,&dAG          : dAG>>=2
lsl.w      #2,&dAG          : shift word back
asr.w      #2,&dAG          : dAG>>=2
move.l     &dAG,(&addr2)    : *(short *)addr2=dAG
asr.l      #1,&dBH          : dBH>>=1
lsl.w      #1,&dBH          : shift word back
asr.w      #1,&dBH          : dBH>>=1
add.l      &dBH,&dBH        : dBH<=1
move.l     &dBH,(&addr3)   : *(short *)addr3=dBH

```

endm

```

-----
macro
BwdV        &base,&end,&inc

movea.l    &base,a0          : addr0=base
move.l     &inc,d0           : d0=inc
asr.l      #2,d0             : d0=inc>>2
movea.l    a0,a3             : addr3=addr0
suba.l     d0,a3             : addr3-=inc>>2
movea.l    a3,a2             : addr2=addr3
suba.l     d0,a2             : addr2-=inc>>2
movea.l    a2,a1             : addr1=addr2
suba.l     d0,a1             : addr1-=inc>>2
BwdStartV0 a0,d4,d5,d7       : BwdStart0(addr0,dAG,dAH,dBH)
adda.l     &inc,a1           : addr1+=inc
BwdStartV1 a1,a0,d4,d5,d7    : BwdStart1(addr1,addr0,dAG,dAH,dBH)
adda.l     &inc,a2           : addr2+=inc
BwdEvenV   a2,d4,d5,d6,d7    : BwdEven(addr2,dAG,dAH,dBG,dBH)
adda.l     &inc,a3           : addr3+=inc
BwdOddV     a3,a2,a1,d4,d5,d6,d7 : BwdOdd(addr3,addr2,addr1,dAG,dAH,dBG)
adda.l     &inc,a0           : addr0+=inc
BwdEvenV    a0,d6,d7,d4,d5    : BwdEven(addr0,dBG,dBH,dAG,dAH)
adda.l     &inc,a1           : addr1+=inc
BwdOddV     a1,a0,a3,d6,d7,d4,d5 : BwdOdd(addr1,addr0,addr3,dBG,dBH,dAG)
adda.l     &inc,a2           : addr2+=inc
cmpa.l     a2,&end           : addr2<end
bgt.s      @do              : while
BwdEndV2    a2,d4,d5,d7      : BwdEnd2(addr2,dAG,dAH,dBH)
adda.l     &inc,a3           : addr3-=inc

```

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Engineering:KlicsCode:CompPact:Backward:a

BwdEndV3 a3,a2,a1,d4,d5,d7 : BwdEnd3(addr3,addr2,addr1,dAG,dAH,dB

endm

Back3511V FUNC EXPORT

```

PS      RECORD      8
data    DS.L         1
incl    DS.L         1
endl    DS.L         1
inc2    DS.L         1
end2    DS.L         1
        ENDR

        link         a6,#0           ; no local variables
        movem.l      d4-d7/a3-a5,-(a7) ; store registers

        move.l       PS.incl(a6),d3   ; inc=incl
        movea.l      PS.data(a6),a5   ; base=data
3do     movea.l      a5,a4             ; end=base
        adda.l       PS.end1(a6),a4    ; end+=endl
        BwdV         a5,a4,d3         ; Bwd(base,end,inc)
        adda.l       PS.inc2(a6),a5    ; base+=inc2
        cmpa.l       PS.end2(a6),a5    ; end2>base
        bit.w        0do              ; for

        movem.l      (a7)+,d4-d7/a3-a5 ; restore registers
        unlk         a6               ; remove locals
        rts          ; return

```

ENDFUNC

macro

BwdStartH &addrR,&A,&C

```

move.l   (&addrR)+,&A      ; 1H1G=*(long *)&addrR
move.l   &A,d0              ; A=1H1G, d0=1H1G
move.l   &A,&C              ; A=1H1G, d0=1H1G, C=1H1G
add.w    &A,d0              ; A=1H1G, d0=1H2G, C=1H1G
add.w    d0,&A              ; A=1H3G, d0=1H2G, C=1H1G
add.w    &A,d0              ; A=1H3G, d0=1H5G, C=1H1G
swap     &A                 ; A=3GH1, d0=1H5G, C=1H1G
sub.l    d0,&A              ; A=AAAA, d0=1H5G, C=1H1G

```

endm

macro

BwdCycleH &addrR,&addrW,&A,&B,&C

```

move.l   (&addrR)+,&B      ; 1H1G=*(long *)&addrR
move.l   &B,d0              ; B=1H1G, d0=1H1G
add.l    d0,d0              ; B=1H1G, d0=2H2G
move.l   d0,d1              ; B=1H1G, d0=2H2G, d1=2H2G
add.l    &B,d0              ; B=1H1G, d0=3H3G, d1=2H2G
add.l    d0,d1              ; B=1H1G, d0=3H3G, d1=5H5G
move.l   &B,d2              ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H1G
move.w   d1,d2              ; B=1H1G, d0=3H3G, d1=5H5G, d2=1H5G
move.w   &B,d1              ; B=1H1G, d0=3H3G, d1=5H1G, d2=1H5G
move.w   d0,&B              ; B=1H3G, d0=3H3G, d1=5H1G, d2=1H5G
move.w   d1,d0              ; B=1H3G, d0=3H1G, d1=5H1G, d2=1H5G
swap     &B                 ; B=3G1H, d0=3H1G, d1=5H1G, d2=1H5G
swap     d0                 ; B=3G1H, d0=1G3H, d1=5H1G, d2=1H5G

```

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Engineering:KlidsCode:CompPict:Backward.a

```

sub.l      d2,&B      ; B=3G1H-1H5G
add.l      d0,&A      ; A+=1H3G
add.l      d1,&A      ; A+=5G1H

asr.w      #2,&A      ; A0>>=2
move.w     &A,&C      ; C complete
asr.l      #2,&A      ; A1>>=2
move.l     &C,(&addrW)+ ; *(long *)addrW=DD
move.l     &A,&C      ; C=A1XX

```

endm

```

macro
BwdEndH

```

&addrR,&addrW,&A,&B,&C

```

move.l     (&addrR)+,d0 ; 1H1G=*(long *)addrR
move.w     d0,d2        ; d2=1G
lsl.w      #2,d2        ; d2=4G
neg.w      d2          ; d2=-4G
swap       d0          ; d0=1G1H
add.w      d0,d2        ; d2+=1H
move.l     d0,d1        ; d0=1G1H, d1=1G1H
add.w      d0,d1        ; d0=1G1H, d1=1G2H
add.w      d1,d0        ; d0=1G3H, d1=1G2H
add.w      d0,d1        ; d0=1G3H, d1=1G5H
swap       d1          ; d0=1G3H, d1=5H1G
add.l      d0,&A      ; A+=1G3H
add.l      d1,&A      ; A+=5H1G

asr.w      #2,&A      ; A1>>=2
move.w     &A,&C      ; C complete
asr.l      #2,&A      ; A0>>=2
move.l     &C,(&addrW)+ ; *(long *)addrW=C
move.w     d2,&A      ; A=D1D2
move.l     &A,(&addrW)+ ; *(long *)addrW=A

```

endm

```

macro
BwdH

```

&base,&end,&inc

```

movea.l    &base,a0      ; addrR=base
movea.l    a0,a1        ; addrW=addrR
BwdStartH  a0,d3,d5      ; BwdStart(addrR,A,DD)
BwdCycleH  a0,a1,d3,d4,d5 ; BwdCycle(addrR,addrW,A,B,C)
BwdCycleH  a0,a1,d4,d3,d5 ; BwdCycle(addrR,addrW,B,A,C)
cmpa.l     a0,&end      ; addr2<end
bgt.s      @do          ; while
BwdEndH    a0,a1,d3,d4,d5 ; BwdEnd(addrR,addrW,A,B,DD)

```

endm

```

Back3511H  FUNC  EXPORT

```

```

PS         RECORD      8
data       DS.L         1
incl       DS.L         1
endl       DS.L         1
inc2       DS.L         1
end2       DS.L         1
ENDR

```

```

link       a6,a0      ; no local variables

```

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Engineering:KlicsCode:CompPic:Backward.a

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```

movem.l    d4-d7/a3-a5, -(a7)    ; store registers
move.l     PS.inc1(a6), d3        ; inc=inc1
movea.l    PS.data(a6), a5        ; base=data
@do        a5, a4                  ; end=base
adda.l     PS.end1(a6), a4        ; end+=end1
BwdH       a5, a4, d3             ; Bwd(base, end, inc)
adda.l     PS.inc2(a6), a5        ; base+=inc2
cmpa.l     PS.end2(a6), a5        ; end2>base
blc.w      @do                   ; for

movem.l     (a7)+, d4-d7/a3-a5    ; restore registers
unlk       a6                    ; remove locals
rts        ; return

ENDFUNC
-----
END

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

.....
*   © Copyright 1993 KLICS Limited
*   All rights reserved.
*
*   Written by: Adrian Lewis
*
...../
/*
*   Full still/video Knowles-Lewis Image KlicsEncode System utilising HVS property
*   and delta-tree coding
*
*   Recoded and re-rationalised (Stand alone version)
*/

#include    <PixMath.h>
#include    "Bits3.h"
#include    "Klics.h"
#include    "KlicsHeader.h"
#include    "KlicsEncode.h"

#include    <Math.h>

/* If bool true the negate value */
#define negif(bool,value)  ((bool)?-(value):(value))
#define abs(value)        negif(value<0,value)

extern void  HaarForward();
extern void  Daub4Forward();

/* Use the bit level file macros (Bits2.h)
buf_use;*/

/* Huffman encode a block */
#define HuffEncLev(lev,buf) \
    HuffEncode(lev[0],buf); \
    HuffEncode(lev[1],buf); \
    HuffEncode(lev[2],buf); \
    HuffEncode(lev[3],buf);

/* Fixed length encode block of integers */
#define IntEncLev(lev,lpf_bits,buf) \
    IntEncode(lev[0],lpf_bits,buf); \
    IntEncode(lev[1],lpf_bits,buf); \
    IntEncode(lev[2],lpf_bits,buf); \
    IntEncode(lev[3],lpf_bits,buf);

/* Define write a zero */
#define Token0 \
    buf_winc(buf);

/* Define write a one */
#define Token1 \
    buf_set(buf); buf_winc(buf);

/* Write block for data and update memory */
#define DoXfer(addr,pro,lev,dst,mode,oct,nmode,buf) \
    HuffEncLev(lev,buf); \
    PutData(addr,pro,dst); \
    mode[oct]=oct==0?M_STOP:nmode;

/* Function Name:  Quantize

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

• Description: H.261 style quantizer
 • Arguments: new, old - image blocks
 pro, lev - returned values
 q - quantizing divisor
 • Returns: lev is all zero, quantized data (pro) & level (lev)

```

boolean Quantize(int new[4], int old[4], int pro[4], int lev[4], short q)
{
    int blk, half_q=(1<<q)-1>>1;
    for(blk=0;blk<4;blk++) {
        int data=new[blk]-old[blk],
            mag_level=abs(data)>>q;

        mag_level=mag_level>135?135:mag_level;
        lev[blk]=negif(data<0,mag_level);
        pro[blk]=old[blk]-negif(data<0,(mag_level<<q)+(mag_level!=0?half_q:0));
    }
    return(pro[0]==0 && pro[1]==0 && pro[2]==0 && pro[3]==0);
}

```

```

void QuantizeLPF(int new[4],int pro[4],int lev[4],short q)
{
    int blk, half_q=(1<<q)-1>>1;
    for(blk=0;blk<4;blk++) {
        int data=new[blk],
            mag_level=abs(data)>>q;

        lev[blk]=negif(data<0,mag_level);
        pro[blk]=(lev[blk]<<q)+half_q;
    }
}

```

/* Function Name: GuessQuantize
 • Description: Estimate threshold quantiser value
 • Arguments: new, old - image blocks
 q - q weighting factor
 • Returns: estimated q_const

```

float GuessQuantize(int new[4],int old[4],float q)
{
    int blk;
    float qt_max=0.0;
    for(blk=0;blk<4;blk++) {
        int i, data=abs(new[blk]-old[blk]);
        float qt;

        for(i=0;data!=0;i++) data>>=1;
        if (i>0) i--;
        qt=((1<<i)-1)>>1/q;

        qt_max=qt_max>qt?qt_max:qt;
    }
    return(qt_max);
}

```

/* Function Name: IntEncode
 • Description: Write a integer to bit file
 • Arguments: lev - integer to write now signed

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

bits = no of bits
*/

void IntEncode(int lev, int bits, Buf buf)
{
    /* Old version
    int i;

    for(i=bits-1; i>=0; i--) {
        if (lev & (1<<i)) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* New version
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1<<bits-2; i!=0; i>=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
    */
    /* Hardware compatible version: sign mag(lsb->msb) */
    int i, mag=abs(lev);
    Boolean sign=lev<0;

    if (1<<bits-1 <= mag) mag=(1<<bits-1)-1;
    if (sign) buf_set(buf);
    buf_winc(buf);
    for(i=1; i!=1<<bits-1; i<=1) {
        if (mag&i) buf_set(buf);
        buf_winc(buf);
    }
}

/* Function Name: HuffEncodeSA
* Description: Write a Huffman coded integer to bit file
* Arguments: lev - integer value
* Returns: no of bits used
*/

void HuffEncode(int lev, Buf buf)
{
    /* int level=abs(lev);

    if (level>1) buf_set(buf);
    buf_winc(buf);
    if (level>2 || level==1) buf_set(buf);
    buf_winc(buf);
    if (level!=0) {
        if (lev<0) buf_set(buf);
        buf_winc(buf);
        if (level>2) {
            int i;

            for(i=3; i<level; i++) {
                buf_winc(buf);
            }
            buf_set(buf);
            buf_winc(buf);
        }
    }
    */
}

```


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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    */
/* New version */
int level=abs(lev), i;

if (level!=0) buf_set(buf);
buf_winc(buf);
if (level!=0) {
    if (lev<0) buf_set(buf);
    buf_winc(buf);
    if (level<8) {
        while (1<level--)
            buf_winc(buf);
        buf_set(buf);
        buf_winc(buf);
    } else {
        for(i=0;i<7;i++)
            buf_winc(buf);
        level-=8;
        for(i=1<=6;i!=0;i>=1) {
            if (level&i) buf_set(buf);
            buf_winc(buf);
        }
    }
}

/* Function Name: KlicsEChannel
 * Description: Encode a channel of image
 * Arguments: src - source channel memory
 *            dst - destination memory (and old for videos)
 *            octs, size - octaves of decomposition and image dimensions
 *            normals - HVS weighted normals
 *            lpf_bits - no of bits for LPP integer (image coding only)
 */

void KlicsEncY(short *src, short *dst, int octs, int size[2], int thresh[5], int co)
{
    int oct, mask, x, y, sub, tmp, step=2<<octs, blk[4], mode[4], nz, no, base;
    int addr[4], new[4], old[4], pro[4], lev[4], zero[4]={0,0,0,0};
    Boolean nzflag, noflag, origin;
    int bitmask=-1<<kle->seqh.precision-kle->frmh.quantizer[0]-1;
    Buf buf=&kle->buf;

    for(y=0;y<size[1];y+=step)
    for(x=0;x<size[0];x+=step)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] |= M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
                case M_VOID:
                    GetData(addr,old,dst);
                    if (BlkZero(old)) mode[oct]=M_STOP;
                    else { DoZero(addr,dst,mode,oct); }
                    break;
                case M_SEND|M_STILL:
                    GetData(addr,new,src);
                    nz=Decide(new); nzflag=nz<=thresh[octs-oct];
                    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-oct))
                        GetData(addr,old,dst);
            }
        } while (mask);
    }
}

```

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```

Engineering:KlicsCode:CompPict:KlicsEnc.c

if (BlkZero(old)) {
    Token0;
    mode{oct}=M_STOP;
} else {
    Token1: Token1;
    DoZero(addr,dst,mode,oct);
}
else {
    Token1: Token0;
    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
}
break;
case M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (BlkZero(old)) {
        if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-o
            Token0;
            mode{oct}=M_STOP;
        } else {
            Token1: Token0;
            DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
        }
    } else {
        int oz=Decide(old), no=DecideDelta(new,old);
        Boolean motion=(nz+oz)>>oct <= no; /* motion detection */
        no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
        origin=nz<=no;
        if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
            if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer(o
                Token1: Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                if (origin) {
                    Token1: Token0;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
                } else {
                    Token1: Token1; Token1;
                    DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
                }
            }
        } else {
            if ((motion || origin) && nzflag) { /* was origin && nzfla
                Token1: Token1; Token0;
                DoZero(addr,dst,mode,oct);
            } else {
                Token0;
                mode{oct}=M_STOP;
            }
        }
    }
break;
case M_STILL:
    GetData(addr,new,src);
    nz=Decide(new); nzflag=nz<=thresh{octs-oct};
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-oct})
        Token0;
        mode{oct}=M_STOP;
    } else {
        Token1;
        DoXfer(addr,pro,lev,dst,mode,oct,M_STILL,buf);
    }

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

    }
    break;
case M_LPF|M_STILL:
    GetData(addr,new,src);
    QuantizeLPP(new,pro,lev,kle->frmh.quantizer[0]);
    VerifyData(lev[0],bitmask,tmp);
    VerifyData(lev[1],bitmask,tmp);
    VerifyData(lev[2],bitmask,tmp);
    VerifyData(lev[3],bitmask,tmp);
    IntEncLev(lev,kle->seqh.precision-kle->frmh.quantizer[0],buf);
    PutData(addr,pro,dst);
    mode[oct]=M_QUIT;
    break;
case M_LPF|M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    no=DecideDelta(new,old); noflag=no<=compare(octs-oct);
    if (noflag) {
        Token0;
    } else {
        Token1;
        Quantize(new,old,pro,lev,kle->frmh.quantizer[0]);
        HuffEncLev(lev,buf);
        PutData(addr,pro,dst);
    }
    mode[oct]=M_QUIT;
    break;
}
switch(mode[oct]) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode[oct]!=M_QUIT);
}

void KlicsEncUV(short *src,short *dst,int octs,int size[2],int thresh[5], int c
{
    int oct, mask, x, y, X, Y, sub, tmp, step=4<<octs, blk[4], mode[4], nz, no
    int addr[4], new[4], old[4], pro[4], lev[4], zero[4]={0,0,0,0};
    Boolean nzflag, noflag, origin;
    int bitmask=-1<<kle->seqh.precision-kle->frmh.quantizer[0]-1;
    Buf buf=&kle->buf;

    for(Y=0;Y<size[1];Y+=step)
    for(X=0;X<size[0];X+=step)
    for(y=Y;y<size[1] && y<Y+step;y+=step>>1)
    for(x=X;x<size[0] && x<X+step;x+=step>>1)
    for(sub=0;sub<4;sub++) {
        mode[oct=octs-1]=base_mode;
        if (sub==0) mode[oct=octs-1] != M_LPF;
        mask=2<<oct;
        do {
            GetAddr(addr,x,y,sub,oct,size,mask);
            switch(mode[oct]) {
            case M_VOID:
                GetData(addr,old,dst);

```

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Engineering: KlicsCode: CompPict: KlicsEnc.c

```

if (BlkZero(old)) mode{oct}=M_STOP;
else { DoZero(addr,dst,mode,oct); }
break;
case M_SENDIM_STILL:
  GetData(addr,new,src);
  nz=Decide(new); nzflag=nz<=thresh{octs-oct};
  if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-oct}))
    GetData(addr,old,dst);
    if (BlkZero(old)) {
      Token0;
      mode{oct}=M_STOP;
    } else {
      Token1; Token1;
      DoZero(addr,dst,mode,oct);
    }
  } else {
    Token1; Token0;
    DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
  }
break;
case M_SEND:
  GetData(addr,new,src);
  GetData(addr,old,dst);
  nz=Decide(new); nzflag=nz<=thresh{octs-oct};
  if (BlkZero(old)) {
    if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer{octs-o
      Token0;
      mode{oct}=M_STOP;
    } else {
      Token1; Token0;
      DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
    }
  }
  } else {
    int oz=Decide(old), no=DecideDelta(new,old);
    Boolean motions=(nz+oz)>>oct <= no; /* motion detection */
    no=DecideDelta(new,old); noflag=no<=compare{octs-oct};
    origin=nz<=no;
    if ((!noflag || motion) && !nzflag) { /* was !noflag && !nzfl
    if (Quantize(new,origin?zero:old,pro,lev,kle->frmh.quantizer{o
      Token1; Token1; Token0;
      DoZero(addr,dst,mode,oct);
    } else {
      if (origin) {
        Token1; Token0;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SENDIM_STILL,buf);
      } else {
        Token1; Token1; Token1;
        DoXfer(addr,pro,lev,dst,mode,oct,M_SEND,buf);
      }
    }
  }
  } else {
    if ((motion || origin) && nzflag) { /* was origin && nzfla
    Token1; Token1; Token0;
    DoZero(addr,dst,mode,oct);
  } else {
    Token0;
    mode{oct}=M_STOP;
  }
  }
  }
break;
case M_STILL:

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

```

GetData(addr,new,src);
nz=Decide(new); nzflag=nz<=thresh[octs-oct];
if (nzflag || Quantize(new,zero,pro,lev,kle->frmh.quantizer(octs-oct);
    Token0;
    mode[oct]=M_STOP;
} else {
    Token1;
    DoXfer(addr,pro,lev,dst,mode,oct,M_STILL,buf);
}
break;
case M_LPF|M_STILL:
    GetData(addr,new,src);
    QuantizeLPF(new,pro,lev,kle->frmh.quantizer(0));
    VerifyData(lev[0],bitmask,tmp);
    VerifyData(lev[1],bitmask,tmp);
    VerifyData(lev[2],bitmask,tmp);
    VerifyData(lev[3],bitmask,tmp);
    IntEncLev(lev,kle->seqh.precision-kle->frmh.quantizer(0),buf);
    PutData(addr,pro,dst);
    mode[oct]=M_QUIT;
    break;
case M_LPF|M_SEND:
    GetData(addr,new,src);
    GetData(addr,old,dst);
    no=DecideDelta(new,old); noflag=no<=compare(octs-oct);
    if (noflag) {
        Token0;
    } else {
        Token1;
        Quantize(new,old,pro,lev,kle->frmh.quantizer(0));
        HuffEncLev(lev,buf);
        PutData(addr,pro,dst);
    }
    mode[oct]=M_QUIT;
    break;
}
switch(mode[oct]) {
case M_STOP:
    StopCounters(mode,oct,mask,blk,x,y,octs);
    break;
case M_QUIT:
    break;
default:
    DownCounters(mode,oct,mask,blk);
    break;
}
} while (mode[oct]!=M_QUIT);
}

/* index to quant and vice versa */
#define i2q(i) (float)i*HISTO_DELTA/(float)HISTO
#define q2i(q) Fix2Long(X2Fix(q*(float)HISTO/HISTO_DELTA))

/* Function Name: LookAhead
* Description: Examine base of tree to calculate new quantizer value
* Arguments: src - source channel memory
*            dst - destination memory (and old for videos)
*            octs - size - octaves of decomposition and image dimensions
*            norms - base HVS weighted normals
* Returns: calculates new quant
*/

```

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Engineering: KlicsCode: CompPict: KlicsEnd.c

```

void LookAhead(short *src, short *dst, float norms[5][3], KlicsE kle)
{
    int x, y, sub, index, size[2] = {kle->seqh.sequence_size[0], kle->seqh.sequence_size[1]};
    thresh[HISTO], quact[HISTO], target;
    int new[4], old[4], addr[4], zero[4] = {0, 0, 0, 0};
    float quant;

    for(index=0; index<HISTO; index++) {
        thresh[index]=0;
        quact[index]=0;
    }

    for(y=0; y<size[1]; y+=2<<octets)
        for(x=0; x<size[0]; x+=2<<octets)
            for(sub=1; sub<4; sub++) {
                float q_thresh;
                int nz, no, oz, blk;
                Boolean ozflag, origin, motion;

                GetAddr(addr, x, y, sub, octets-1, size, 1<<octets);
                GetData(addr, new, src);
                GetData(addr, old, dst);
                nz=Decide(new);
                oz=Decide(old);
                no=DecideDelta(new, old);
                ozflag=kle->encd.intra || BlkZero(old);
                origin=nz<=no;
                motion=(nz+oz)>>octets <= no;
                q_thresh=(float)nz/DecideDouble(norms[1][1]);
                if (ozflag || origin) {
                    float qt=GuessQuantize(new, zero, norms[1][0]);

                    q_thresh=q_thresh<qt?q_thresh:qt;
                } else {
                    float qt=GuessQuantize(new, old, norms[1][0]);

                    q_thresh=q_thresh<qt?q_thresh:qt;
                    if (!motion) {
                        qt=(float)no/DecideDouble(norms[1][2]);
                        q_thresh=q_thresh<qt?q_thresh:qt;
                    }
                }
                index=q2i(q_thresh);
                index=index<0?0:index>HISTO-1?HISTO-1:index;
                thresh[index]++;
            }

    for(index=HISTO-1; index>=0; index--)
        quact[index]=thresh[index]*index+(index==HISTO-1?0:quact[index+1]);

    /* buffer must be greater than bfp_in after this frame */
    /* buffer must be less than buff_size+bfp_in */
    target=kle->encd.bpf_out*kle->encd.prevquact/kle->encd.prevbytes; /* previous
    index=1;
    while(index<HISTO && quact[index]/index>target) index++;
    quant=i2q(index);

    kle->encd.tmp_quant=(kle->encd.tmp_quant+quant)/2.0;
    kle->encd.tmp_quant=i2q((index=q2i(kle->encd.tmp_quant))); /* forward and reve
    kle->encd.prevquact=quact[index]/(index==0?1:index);
}

/* Function Name: BaseNormals

```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

- Description: Calculates base HVS weighted normals
- Arguments: norms - storage for normals
- Returns: weighted normals

```
void BaseNormals(float norms[5][3],KlicsE kle)
{
    float base_norm[3]=(1.0,kle->encl.thresh,kle->encl.compare);
    int norm, oct;

    for(oct=0;oct<5;oct++)
        for(norm=0;norm<3;norm++)
            norms[oct][norm]=base_norm[norm]*kle->encl.base[oct]*(float)(1<<kl)
}

/* Function Name: Normals
 * Description: Calculates HVS weighted normals @ quant
 * Arguments: norms - storage for normals
 * Returns: weighted normals and LPF bits
 */
```

```
void Normals(float base_norms[5][3],int thresh[5],int compare[5],KlicsE kle)
{
    int oct, i, norm;

    for(oct=0;oct<=kle->seqh.octaves[0];oct++) {
        norm=Fix2Long(X2Fix(base_norms[oct][0]*kle->encl.tmp_quant));
        norm=norm<171?norm:
        for(i=0;i!=(norm&~3);i++)
            norm=norm>>1;
        switch(norm) {
            case 1:
                kle->frmh.quantizer[oct]=i;
                break;
            case 2:
                kle->frmh.quantizer[oct]=i+1;
                break;
            case 3:
            case 4:
                kle->frmh.quantizer[oct]=i+2;
        }
        thresh[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][1]*kle->encl.tmp_q
        compare[oct]=Fix2Long(X2Fix(DecideDouble(base_norms[oct][2]*kle->encl.tmp_
    )
    kle->frmh.quantizer[0]=kle->frmh.quantizer[0]<3?3:kle->frmh.quantizer[0];
    /* minimum 4 bits of quant for lpf due to dynamic range problems */
}
```

```
Boolean KlicsFlags(KlicsE kle)
```

```
{
    Boolean skip=false;

    kle->encl.buffer=kle->encl.bpf_in;
    kle->frmh.flags=0;
    if (kle->encl.buffer<0)
        kle->encl.buffer=0;
    if (kle->encl.intra)
        kle->frmh.flags |= KFH_INTRA;
    else
        if (skip=kle->encl.buf_sw && kle->encl.buffer>=kle->encl.buf_size)
            kle->frmh.flags |= KFH_SKIP;
    return(skip);
}
```

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Engineering:KlicsCode:CompPict:KlicsEnc.c

* Function Name: KlicsEncode
 * Description: Encode a frame from YUV (de)transformed image
 * Arguments: src - source image(s)
 dst - transformed destination memory (and old for videos)

```

long KlicsEncode(short *src[3], short *dst[3], KlicsE kle)
{
    float base_norms[5][3];
    int channel, thresh[5], compare[5];
    Buf buf=&kle->buf;

    buf_winit(buf);
    if (KlicsFlags(kle))
        kle->frmh.length=0;
    else {
        for(channel=0; channel<kle->seqh.channels; channel++) {
            int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.sub_s
                area=size[0]*size[1], octs=kle->seqh.octaves(channel==0?0:

            switch(kle->seqh.waveler) {
                case WT_Haar:
                    HaarForward(src[channel], size, octs);
                    break;
                case WT_Daub4:
                    Daub4Forward(src[channel], size, octs);
                    break;
            }
        }
        BaseNormals(base_norms, kle);
        if (kle->encd.auto_q && !kle->encd.intra)
            LookAhead(src[0], dst[0], base_norms, kle);
        else
            kle->encd.tmp_quant=kle->encd.quant;
        Normals(base_norms, thresh, compare, kle);
        for(channel=0; channel<kle->seqh.channels; channel++) {
            int size[2]=(kle->seqh.sequence_size[0]>>(channel==0?0:kle->seqh.s
                kle->seqh.sequence_size[1]>>(channel==0?0:kle->seqh.sub_s
                octs=kle->seqh.octaves(channel==0?0:1);

            if (kle->encd.intra)
                KLZERO(dst[channel], size[0]*size[1]);
            if (channel==0) KlicsEncY(src[channel], dst[channel], octs, size, thresh, c
            else KlicsEncUV(src[channel], dst[channel], octs, size, thresh, compare, kle
        }
        buf_flush(buf);
        kle->frmh.length=buf_size(buf);
        kle->encd.buffer=&kle->frmh.length;
        if (!kle->encd.intra)
            kle->encd.prevbytes=kle->frmh.length;
    }
    return(kle->frmh.length);
}
  
```


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Engineering:KlicsCode:CompPict:KlicsHeader.h

```

.....
*
*  © Copyright 1993 KLIICS Limited
*  All rights reserved.
*
*  Written by: Adrian Lewis
*
*...../
*
*  Sequence and frame headers for Klics-Encoded files
*  High byte first
*
typedef struct (
    unsigned short  description_length; /* Fixed      - Size of this or parent struc
    unsigned char   version_number[2]; /* Fixed      - Version and revision numbers
) KlicsHeader;

typedef struct (
    KlicsHeader head;
    unsigned short sequence_size[3]; /* Fixed      - Size and version of this str
    unsigned char  channels;          /* Source    - Luminance dimensions and num
    unsigned char  sub_sample[2];     /* Source    - Number of channels: 3 - YUV,
    unsigned char  wavelet;           /* Source    - UV sub-sampling in X and Y d
    unsigned char  precision;         /* Source    - Wavelet used: 0 - Haar, 1 -
    unsigned char  octaves[2];        /* Source    - Bit precision for transform
    unsigned char  reserved[3];       /* Fixed     - Number of octaves Y/UV (maxi
) KlicsSeqHeader;

typedef struct (
    KlicsHeader head;
    unsigned long  length;             /* Fixed     - Size and version of this str
    unsigned long  frame_number;       /* Calc      - Length of frame data (bytes)
    unsigned char  flags;              /* Calc      - Frame number intended for se
    unsigned char  quantizer[5];       /* Calc      - Bitfield flags: 0 - frame sk
    unsigned short reserved;           /* Fixed     - Quantiser shift values{octav
) KlicsFrameHeader;

#define KFH_SKIP      0x1
#define KFH_INTRA     0x2

/*
*  Implementation notes :
*  QuickTime  Must have KlicsFrameHeader.length set to a valid number
*  Sun        Must have KlicsSeqHeader in data stream
*
*  Possible developments:
*  KlicsFrameHeader.quantizer
*  Currently contains shift rather than step-size
*  Different values for UV and GH, HG, GG sub-bands are not currently suppo
*/

```

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Engineering:KlicsCode:Klics Codec:KlicsEncode.r

```
/*
 * KlicsEncode resource file
 */
```

```
#include "Types.r"
#include "MPWTypes.r"
#include "ImageCodec.r"
```

```
/*
 * Klics Compressor included into the applications resource file here
 */
```

```
#define klicsCodecFormatName    "Klics"
#define klicsCodecFormatType    'klic'
```

```
/*
```

This structure defines the capabilities of the codec. There will probably be a tool for creating this resource, which measures the performance and capabilities of your codec.

```
*/
resource 'cdci' (129, "Klics CodecInfo", locked) (
    klicsCodecFormatName,          /* name of the codec TYPE ( da
    1,                             /* version */
    1,                             /* revision */
    'klic',                        /* who made this codec */
    0,
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal, /* depth and etc suppo
    codecInfoDepth24|codecInfoSequenceSensitive,          /* which data formats do we un
    100,                         /* compress accuracy (0-255) (
    100,                         /* decompress accuracy (0-255)
    0,                           /* millisecs to compress 320x2
    0,                           /* millisecs to decompress 320
    0,                           /* compression level (0-255) (
    0,
    32,                           /* minimum height */
    32,                           /* minimum width */
    0,
    0,
    0
);
```

```
resource 'thng' (128, "Klics Compressor", locked) (
    compressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes8|codecInfoDoesTemporal,
    0,
    'cdec',
    128,
    'STR ',
    128,
    'STR ',
    129,
    'ICON',
    128
);
```

```
resource 'STR ' (128) (
    "Klics Compress"
```

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Engineering:KlicsCode:Klics Codec:KlicsEncode.r

resource "STR" (129) (
"Wavelet transform & multiresolution tree based coding scheme"

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Engineering:KlicsCode:Klics Codec:KlicsDecode.r

```

/*
 * KlicsDecode resource file
 */

#include 'Types.r'
#include 'MPATypes.r'
#include 'ImageCodec.r'

/*
 * Klics Compressor included into the applications resource file here
 */

#define klicsCodecFormatName    'Klics'
#define klicsCodecFormatType    'klic'

/*
 * This structure defines the capabilities of the codec. There will
 * probably be a tool for creating this resource, which measures the performance
 * and capabilities of your codec.
 */
resource 'cdci' (129, 'Klics CodecInfo', locked) {
    klicsCodecFormatName, /* name of the codec TYPE ( da
    1, /* version */
    1, /* revision */
    'klic', /* who made this codec */
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    codecInfoDepth24|codecInfoSequenceSensitive, /* which data formats do we un-
    100, /* compress accuracy (0-255) (
    100, /* decompress accuracy (0-255)
    0, /* millisecs to compress 320x2
    0, /* millisecs to decompress 320
    0, /* compression level (0-255) (
    0,
    32, /* minimum height */
    32, /* minimum width */
    0,
    0,
    0
};

resource 'thng' (130, 'Klics Decompressor', locked) {
    decompressorComponentType,
    klicsCodecFormatType,
    'klic',
    codecInfoDoes32|codecInfoDoes16|codecInfoDoes8|codecInfoDoesTemporal|codecInfo
    0,
    'cdec',
    128,
    'STR ',
    130,
    'STR ',
    131,
    'ICON',
    130
};

resource 'STR ' (130) {

```

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CLAIMS

WE CLAIM:

1. A method of transforming a sequence of input digital data values into a first sequence of transformed digital data values and of inverse transforming a second sequence of transformed digital data values into a sequence of output digital data values, said sequence of input digital data values comprising a boundary subsequence and a non-boundary subsequence, comprising the steps of:
 - 10 running a number of said input digital data values of said boundary subsequence through a low pass boundary forward transform perfect reconstruction digital filter and through a high pass boundary forward transform perfect reconstruction digital filter to produce a first subsequence of said first sequence of transformed digital data values, said first subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values;
 - 20 running a number of said input digital data values of said non-boundary subsequence through a low pass non-boundary forward transform perfect reconstruction digital filter and also through a high pass non-boundary forward transform perfect reconstruction digital filter to produce a second subsequence of said first sequence of transformed digital data values, said second subsequence of said first sequence of transformed digital data values comprising interleaved low and high frequency transformed digital data values, said low pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients than said low pass non-boundary forward transform perfect reconstruction digital filter, said high pass boundary forward transform perfect reconstruction digital filter having a fewer number of coefficients

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than said high pass non-boundary forward transform perfect reconstruction digital filter;

converting said first sequence of transformed digital data values into said second sequence of transformed digital data values, said second sequence of transformed digital data values comprising a first subsequence of said second sequence of transformed digital data values and a second subsequence of said second sequence of transformed digital data values;

running a number of said first subsequence of said second sequence of transformed digital data values through an interleaved boundary inverse transform perfect reconstruction digital filter to produce at least one output digital data value;

running a number of said second subsequence of said second sequence of transformed digital data values through a first interleaved non-boundary inverse transform perfect reconstruction digital filter to produce output digital data values; and

running a number of said second subsequence of transformed digital data values through a second interleaved non-boundary inverse transform perfect reconstruction digital filter to produce output digital data values, said output digital data values produced by said interleaved boundary inverse transform perfect reconstruction digital filter, said first interleaved non-boundary inverse transform perfect reconstruction digital filter, and said second interleaved non-boundary inverse transform perfect reconstruction digital filter comprising a subsequence of said output digital data values of said sequence of output digital data values.

2. The method of Claim 1, wherein said low pass boundary forward transform perfect reconstruction digital filter has X coefficients and wherein said low pass non-boundary forward transform perfect reconstruction digital

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filter has Y coefficients, Y being greater than X , said X coefficients of said low pass boundary forward transform perfect reconstruction digital filter being chosen so that said low pass boundary forward transform perfect

- 5 reconstruction digital filter outputs a transformed digital data value H_0 when the low pass boundary forward perfect transform reconstruction digital filter operates on input digital data values ID_0-ID_{X-1} adjacent said boundary, said transformed digital data value H_0 being substantially equal
- 10 to what the output of the low pass non-boundary forward transform perfect reconstruction digital filter would be were the low pass non-boundary forward perfect reconstruction digital filter to operate on ID_0-ID_{X-1} as well as $Y-X$ additional input digital data values outside
- 15 said boundary, said additional input digital data values having preselected values.

3. The method of Claim 2, wherein $Y-X=1$, wherein there is one additional input digital data value ID_{-1} , and wherein ID_{-1} is preselected to be substantially equal to
- 20 ID_0 .

4. The method of Claim 2, wherein $Y-X=1$, wherein there is one additional input digital data value ID_{-1} , and wherein ID_{-1} is preselected to be substantially equal to zero.

- 25 5. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with pixels of either a row or a column of a two dimensional image, said boundary of said sequence of input digital data values corresponding with either a
- 30 start or an end of said row or said column.

6. The method of Claim 1, wherein said sequence of input digital data values is a sequence of digital data values associated with an audio signal.

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7. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are forward transform quasi-perfect reconstruction filters which have coefficients which
 5 approximate the coefficients of true forward transform perfect reconstruction filters.

8. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction digital filters are both four coefficient quasi-Daubechies
 10 filters the coefficients of which approximate the coefficients of true four coefficient Daubechies filters.

9. The method of Claim 8, wherein one of said four coefficient quasi-Daubechies filters has the coefficients 11/32, 19/32, 5/32 and 3/32 independent of sign.

15 10. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter H of the form:

$$H_n = aID_{2n-1} + bID_{2n} + cID_{2n+1} - dID_{2n+2}$$

20 n being a positive integer, ID_0-ID_m being input digital data values, m being a positive integer, ID_0 being the first input digital data value in said sequence of input digital data values, and wherein said low pass boundary forward transform perfect reconstruction digital filter is a three
 25 coefficient digital filter of the form:

$$H_0 = aID_{-1} + bID_0 + cID_1 - dID_2$$

ID_{-1} being a predetermined input digital data value outside said boundary and having a preselected value.

11. The method of Claim 10, wherein said high pass

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non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter of the form:

$$G_n = dID_{2n-1} + cID_{2n} - bID_{2n+1} + aID_{2n+2}$$

5 n being a positive integer, and wherein said high pass boundary forward transform perfect reconstruction digital filter is a three coefficient digital filter of the form:

$$G_0 = dID_{-1} + cID_0 - bID_1 + aID_2$$

dID₋₁ having a preselected value.

10 12. The method of Claim 11, wherein: $a + b + c - d$ is substantially equal to 1, wherein $a - b + c + d$ is substantially equal to 0, and wherein $ac - bd$ is substantially equal to zero.

13. The method of Claim 12, wherein: $a=11/32$,
15 $b=19/32$, $c=5/32$ and $d=3/32$.

14. The method of Claim 11, wherein said interleaved boundary inverse transform perfect reconstruction digital filter is a two coefficient digital filter of the form:

$$OD_0 = 4(b-a)H_0 + 4(c-d)G_0$$

20 wherein OD_0 is an output digital data value of said sequence of output digital data values, wherein G_0 is the output of said high pass boundary forward transform perfect reconstruction digital filter when the high pass boundary forward transform perfect reconstruction digital
25 filter operates on input digital data values ID_0 , ID_1 and ID_2 adjacent said boundary, and wherein H_0 is the output of said low pass boundary forward transform perfect reconstruction digital filter when the low pass boundary

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forward transform perfect reconstruction digital filter operates on input digital data values ID_0 , ID_1 and ID_2 adjacent said boundary.

15. The method of Claim 14, wherein one of said first
5 and second interleaved non-boundary inverse transform perfect reconstruction digital filters is of the form:

$$D_{2n+1} = 2(cH_n - bG_n + aH_{n+1} + dG_{n+1})$$

n being a non-negative integer, and wherein the other of
said first and second interleaved non-boundary inverse
10 perfect reconstruction digital filters is of the form:

$$D_{2n+2} = 2(-dH_n + aG_n + bH_{n+1} + cG_{n+1})$$

n being a non-negative integer, wherein H_n , G_n , H_{n+1} and G_{n+1} comprise a subsequence of said second sequence of transformed digital data values.

15 16. The method of Claim 1, wherein said low pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients: $11/32$, $19/32$, $5/32$ and $-3/32$, and wherein
20 said high pass non-boundary forward transform perfect reconstruction digital filter is a four coefficient quasi-Daubechies filter having the coefficients: $3/32$, $5/32$, $-19/32$ and $11/32$.

17. The method of Claim 1, wherein said low and high pass non-boundary forward transform perfect reconstruction
25 digital filters are chosen from the group consisting of: true six coefficient Daubechies filters and quasi-Daubechies filters, the coefficients of the quasi-Daubechies filters approximating the coefficients of true six coefficient Daubechies filters.

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18. The method of Claim 1, further comprising the steps of:

encoding said first sequence of transformed digital data values into an encoded sequence; and
5 decoding said encoded sequence of digital data values into said second sequence of transformed digital data values and supplying said second sequence of transformed digital data values to said interleaved boundary inverse transform perfect reconstruction
10 digital filter, said first interleaved non-boundary inverse transform perfect reconstruction digital filter, and said second interleaved non-boundary inverse transform perfect reconstruction digital filter.

15 19. The method of Claim 18, further comprising the step of:

quantizing each of said digital data values in said first sequence of transformed values before said encoding step.

20 20. The method of Claim 1, wherein each of said input digital data values of said sequence of input digital data values is stored in a separate memory location, and wherein some of said memory locations are overwritten in a sequence with said sequence of transformed digital data values as
25 said digital data input values are transformed into said transformed digital data values.

21. A method of transforming a sequence of input digital data values into a sequence of transformed digital data values, said sequence of input digital data values
30 comprising a boundary subsequence and a non-boundary subsequence, comprising the steps of:

running a number of said input digital data values of said boundary subsequence through a low pass boundary forward transform perfect reconstruction

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digital filter and through a high pass boundary
forward transform perfect reconstruction digital
filter to produce a first subsequence of said sequence
of transformed digital data values, said first
5 subsequence of said sequence of transformed digital
data values comprising interleaved low and high
frequency transformed digital data values; and

running a number of said input digital data
values of said non-boundary subsequence through a low
10 pass non-boundary forward transform perfect
reconstruction digital filter and also through a high
pass non-boundary forward transform perfect
reconstruction digital filter to produce a second
subsequence of said sequence of transformed digital
15 data values, said second subsequence of said sequence
of transformed digital data values comprising
interleaved low and high frequency transformed digital
data values, said low pass boundary forward transform
perfect reconstruction digital filter having a fewer
20 number of coefficients than said low pass non-boundary
forward transform perfect reconstruction digital
filter, said high pass boundary forward transform
perfect reconstruction digital filter having a fewer
number of coefficients than said high pass non-
25 boundary forward transform perfect reconstruction
digital filter.

22. A method, comprising the steps of:

generating a sub-band decomposition having a
plurality of octaves, a first of said plurality of
30 octaves comprising at least one first digital data
value, a second of said plurality of octaves
comprising at least one second digital data value;

calculating a sum of the absolute values of said
at least one first digital data value;

35 determining if said at least one first digital
data value is interesting using a first threshold

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limit;

calculating a sum of the absolute values of said
at least one second digital data value; and

5 determining if said at least one second digital
data value is interesting using a second threshold
limit.

23. A method of traversing a tree decomposition, said
tree decomposition comprising a plurality of transformed
data values, each of said plurality of transformed data
10 values having a unique address identified by coordinates X
and Y, comprising the step of:

calculating at least four transformed data value
addresses by incrementing a count, the count
comprising one bit $C1_x$ in the X coordinate and one bit
15 $C1_y$ in the Y coordinate, to generate said at least
four transformed data value addresses.

24. A method, comprising the step of:

determining an address of a transformed data value in
a tree decomposition by shifting a value a number of times,
20 said tree decomposition having a number of octaves, said
transformed data value being in one of said octaves, said
number of times being at least dependent upon said one
octave.

25. A method, comprising the step of:

25 determining an address of a transformed data value in
a tree decomposition by multiplying a value by a factor,
said tree decomposition having a number of octaves, said
transformed data value being in one of said octaves, said
factor being at least dependent upon said one octave.

30 26. A method, comprising the step of:

determining an address of a transformed data value in
a tree decomposition by shifting a value a number of times,
said tree decomposition having a number of frequency sub-

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bands, said transformed data value being in one of said frequency sub-bands, said number of times being at least dependent upon said frequency sub-band.

27. A method, comprising the step of:
5 determining an address of a transformed data value in a tree decomposition by performing a logical operation upon a value, said tree decomposition having a number of frequency sub-bands, said transformed data value being in one of said frequency sub-bands, said logical operation
10 performed being at least dependent upon said one frequency sub-band.

28. The method of Claim 27, wherein said logical operation is a bit-wise logical AND operation.

29. A method for determining a low pass quasi-perfect
15 reconstruction filter and a high pass quasi-perfect reconstruction filter from a wavelet function, said low pass quasi-perfect reconstruction filter having a plurality of coefficients, said high pass quasi-perfect reconstruction filter having a plurality of coefficients,
20 comprising the steps of:

determining a low pass wavelet digital filter and a high pass wavelet digital filter from said wavelet function, said low pass wavelet digital filter having a plurality of coefficients, said high pass wavelet digital
25 filter having a plurality of coefficients;

choosing the coefficients of said low pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is processed by said low pass quasi-perfect reconstruction
30 digital filter the output of said low pass quasi-perfect reconstruction digital filter is exactly a power of 2; and

choosing the coefficients of the high pass quasi-perfect reconstruction digital filter to be fractions such that when a sequence of data values having values of 1 is

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processed by said high pass quasi-perfect reconstruction digital filter the output of said high pass quasi-perfect reconstruction digital filter is exactly 0, whereby each of the plurality of coefficients of said low pass quasi-
5 perfect reconstruction digital filter is substantially identical to a corresponding one of said plurality of coefficients of said low pass wavelet digital filter, and whereby each of the plurality of coefficients of said high pass quasi-perfect reconstruction digital filter is
10 substantially identical to a corresponding one of said plurality of coefficients of said high pass wavelet digital filter.

30. A method of estimating a compression ratio of a number of original data values to a number of compressed
15 data values at a value of a quality factor Q, comprising the steps of:

examining a first block of transformed data values of a tree, said first block being one of a number of lowest frequency blocks of a high pass component sub-band, said
20 tree being part of a sub-band decomposition; and

determining a value of said quality factor Q at which said data values of said first block would be converted into compressed data values, and not determining a value of said quality factor Q at which any other block of data
25 values of said tree would be converted into a number of compressed data values.

31. The method of Claim 30, wherein said number of original data values represents a frame of an image.

32. The method of Claim 31, further comprising the
30 step of:

determining a number of lowest frequency blocks of said high pass component sub-band which would be converted into compressed data values given a value of said quality factor Q.

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33. A method of transforming a sequence of image data values, comprising the step of:

filtering said sequence of image data values using a quasi-perfect reconstruction filter to generate a
5 decomposition having a plurality of octaves, said quasi-perfect reconstruction filter having six coefficients.

34. The method of Claim 33, wherein said six coefficients are selected from the group consisting of:
30/128, 73/128, 41/128, 12/128, 7/128 and 3/128,
10 irrespective of sign.

35. A method of detecting motion in a tree decomposition, said tree decomposition comprising a plurality of octaves of blocks of data values, comprising the steps of:

15 comparing data values of a first block in an octave with data values of a second block in said octave; and
generating a token indicating motion based on said comparing.

36. A method, comprising the steps of:
20 generating a sub-band decomposition having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;
25 determining if said at least one first digital data value is interesting using a first threshold limit; and
determining if said at least one second digital data value is interesting using a second threshold limit.

37. A method, comprising the steps of:
30 generating a sub-band decomposition of a first frame having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a

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second of said plurality of octaves comprising at least one second digital data value;

generating a sub-band decomposition of a second frame having a plurality of octaves, a first of said plurality of octaves comprising at least one first digital data value, a second of said plurality of octaves comprising at least one second digital data value;

comparing said first digital data value of said first frame with said first digital data value of said second frame using a first threshold compare; and

comparing said second digital data value of said first frame with said second digital data value of said second frame using a second threshold compare.

38. A method, comprising the steps of:

reading a sequence of data values from a plurality of memory locations, each of said data values being stored in a separate one of said plurality of memory locations; and
overwriting some of said memory locations in a sequence as said data values are transformed into a sequence of transformed data values of a sub-band decomposition.

39. A method, comprising the steps of:

performing a function on a plurality of data values of a new block to generate a first output value, said new block being a block of data values of a sub-band decomposition of a new frame;

performing said function on a plurality of numbers to generate a second output value, each of said numbers substantially equalling a difference of a data value in said plurality of data values of said new block and a corresponding data value in a corresponding plurality of data values of an old block, said old block being a block of data values of a sub-band decomposition of an old frame; and

generating a token if said first output value has a

- 820 -

predetermined relationship with respect to said second output value.

40. The method of Claim 39, wherein said token is a SEND_STILL token.

5 41. A method, comprising the steps of:

performing a function on a plurality of data values of a new block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition;

10 comparing each of said plurality of output values with a predetermined number; and

generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

15 42. The method of Claim 41, wherein said token is a VOID token.

43. A method, comprising the steps of:

subtracting each one of a plurality of data values of a new block with a corresponding one of a plurality of data values of a old block to generate a corresponding plurality of output values, said new block being a block of data values of a sub-band decomposition of a new frame, said old block being a block of data values of a sub-band decomposition of a old frame;

20 25 comparing each of said plurality of output values with a predetermined number; and

generating a token if substantially all of said output values have a predetermined relationship with respect to said predetermined number.

30 44. The method of Claim 43, wherein said token is a VOID token.

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45. A method, comprising the steps of:

determining an absolute value for each of a plurality of data values of a block of a sub-band decomposition;

determining a sum of said absolute values; and

5 generating a token based on a comparison of said sum with a predetermined number.

46. The method of Claim 45, wherein said token is a VOID token.

47. A method, comprising the steps of:

10 processing a sequence of first image data values using a low pass forward transform perfect reconstruction digital filter and a high pass forward transform perfect reconstruction digital filter to create a first sequence of transformed data values, said low pass forward transform
15 perfect reconstruction digital filter and said high pass forward transform perfect reconstruction digital filter each having coefficients chosen from a first group of coefficients independent of sign;

converting said first sequence of transformed data values into a second sequence of transformed data values;
20 and

using digital circuitry to process said second sequence of transformed data values using a low pass inverse transform perfect reconstruction digital filter and
25 a high pass inverse transform perfect reconstruction digital filter into a sequence of second image data values, said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter each having coefficients
30 chosen from a second group of coefficients independent of sign.

48. The method of claim 47, wherein said digital circuitry used to process said second sequence of transformed data values is a digital computer having a

- 822 -

microprocessor.

49. The method of claim 47, wherein at least one of the coefficients in said first group of coefficients is not contained in said second group of coefficients.

5 50. The method of claim 47, wherein said first group of coefficients has a different number of coefficients than said second group of coefficients.

51. The method of claim 50, wherein said sequence of first image data values is a sequence of chrominance data
10 values.

52. The method of claim 50, wherein said low pass forward transform perfect reconstruction digital filter and said high pass forward transform perfect reconstruction digital filter each have four coefficients, and wherein
15 said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter each have two coefficients.

53. The method of claim 52, wherein said sequence of first image data values is a sequence of chrominance data
20 values.

54. The method of claim 47, wherein each of said coefficients of said low pass inverse transform perfect reconstruction digital filter and said high pass inverse transform perfect reconstruction digital filter is selected
25 from the group consisting of: $5/8$, $3/8$ and $1/8$, independent of sign.

55. The method of claim 47, wherein said converting step comprises the steps of:
encoding said first sequence of transformed data
30 values into a compressed data stream; and

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decoding said compressed data stream into said second sequence of transformed data values.

56. A method comprising the step of using digital circuitry to process a sequence of image data values using
5 a low pass forward transform perfect reconstruction digital filter and a high pass forward transform perfect reconstruction digital filter to generate a sub-band decomposition, said low pass forward transform perfect reconstruction digital filter and said high pass forward
10 transform perfect reconstruction digital filter each having four coefficients, each of said four coefficients being selected from the group consisting of: $5/8$, $3/8$ and $1/8$, independent of sign.

57. The method of claim 56, wherein said digital
15 circuitry comprises means for low pass forward transform perfect reconstruction digital filtering and for high pass forward transform perfect reconstruction digital filtering.

58. A method comprising the step of using digital circuitry to process a sequence of transformed data values
20 of a sub-band decomposition using an odd inverse transform perfect reconstruction digital filter and an even inverse transform perfect reconstruction digital filter, said odd inverse transform perfect reconstruction digital filter and said even inverse transform perfect reconstruction digital
25 filter each having four coefficients, each of said four coefficients being selected from the group consisting of: $5/8$, $3/8$ and $1/8$, independent of sign.

59. The method of claim 58, wherein said digital circuitry is a digital computer having a microprocessor.

30 60. A method comprising the step of generating a compressed data stream indicative of a video sequence from a sub-band decomposition, said compressed data stream

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comprising a first data value, a first token, a second data value, and a second token, said first token being indicative of a first encoding method used to encode said first data value, said second token being indicative of a second encoding method used to encode said second data value, said first token consisting of a first number of bits and said second token consisting of a second number of bits.

61. The method of claim 60, wherein said first encoding method is taken from the group consisting of: SEND mode, STILL_SEND mode, VOID mode, and STOP mode.

62. The method of claim 60, wherein said first token is a single bit token.

63. A method, comprising the steps of:

15 forward transforming image data values to generate a first sequence of transformed data values of a first sub-band decomposition, said first sub-band decomposing having a first number of octaves;

converting said first sequence of transformed data values into a second sequence of transformed data values;

20 using digital circuitry to inverse transforming said second sequence of transformed data values into a third sequence of transformed data values, said third sequence of transformed data values comprising a second sub-band decomposition having a second number of octaves, said second number of octaves being smaller than said first number of octaves, said second sub-band decomposition having a low pass component, said low pass component of said second sub-band decomposition comprising data values

25 indicative of rows of data values of an image, said rows of said image extending in a first dimension, said image also having columns of said data values extending in a second dimension;

30 expanding said low pass component in said first

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dimension using interpolation to generate an interpolated low pass component; and

expanding said interpolated low pass component in said second dimension by replicating rows of said data values of 5 said interpolated low pass component.

64. The method of claim 63, wherein said digital circuitry is a digital computer having a microprocessor.

65. The method of claim 63, wherein said converting step comprises the steps of:

10 encoding said first sequence of transformed data values into a compressed data stream comprising tokens and encoded data values; and

decoding said compressed data stream into said second sequence of transformed data values.

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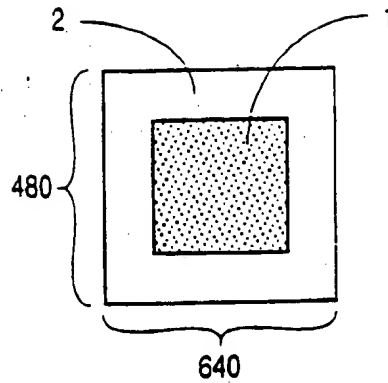


Fig. 1
(PRIOR ART)

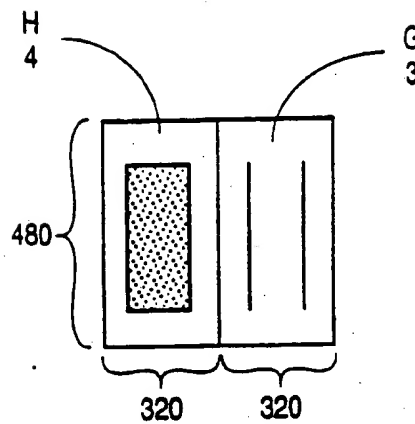


Fig. 2
(PRIOR ART)

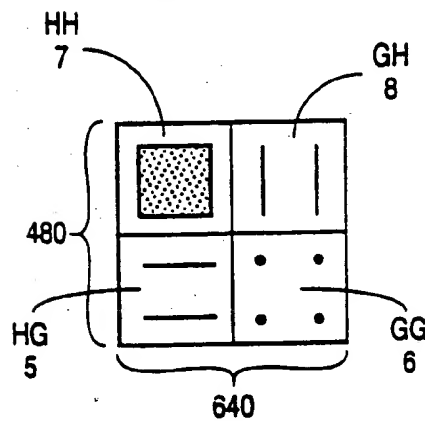


Fig. 3
(PRIOR ART)

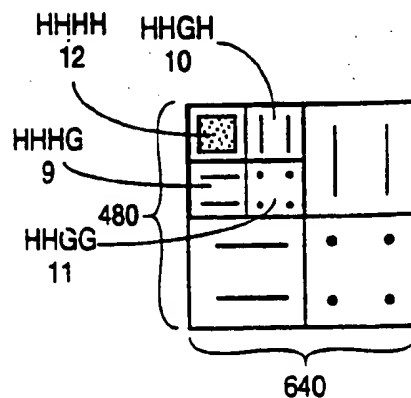


Fig. 4
(PRIOR ART)

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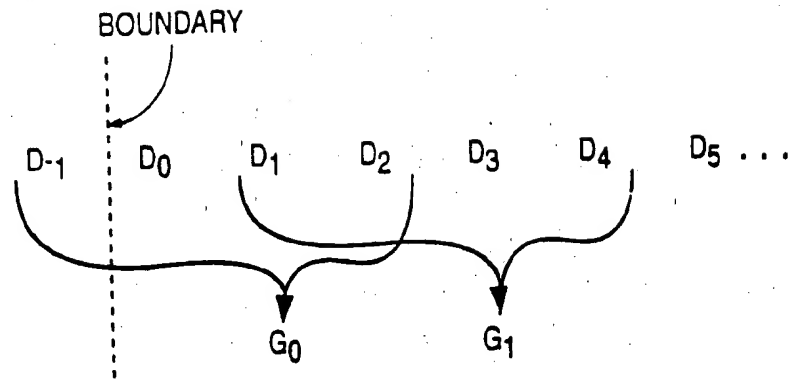


Fig. 5
(PRIOR ART)

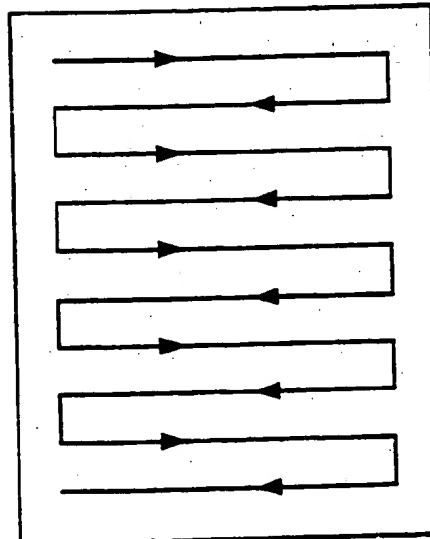


Fig. 6
(PRIOR ART)

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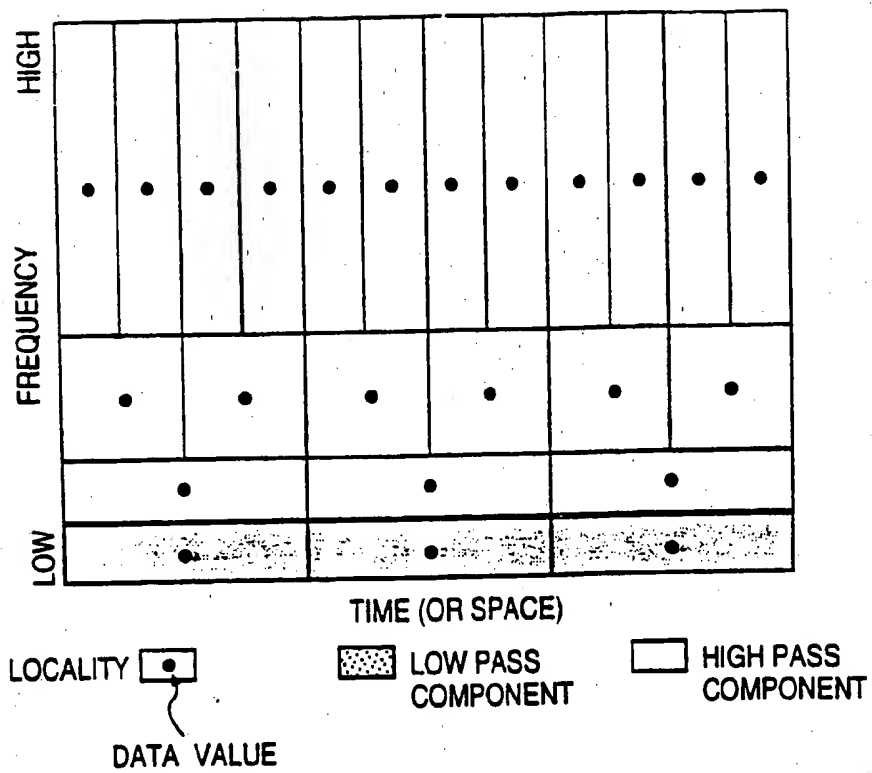


Fig. 7

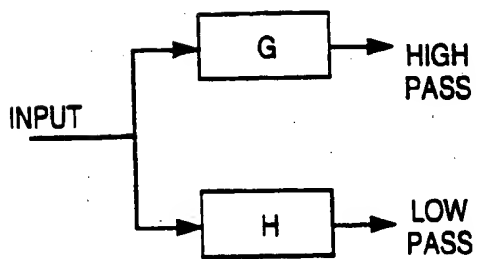


Fig. 8

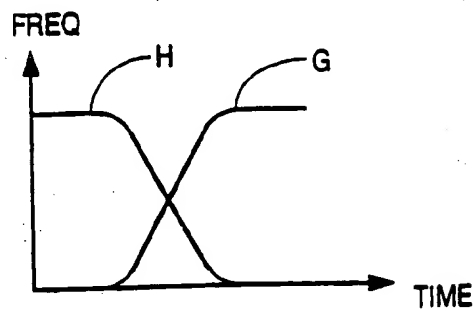


Fig. 9

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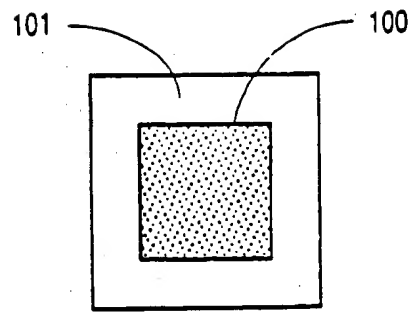


Fig. 10

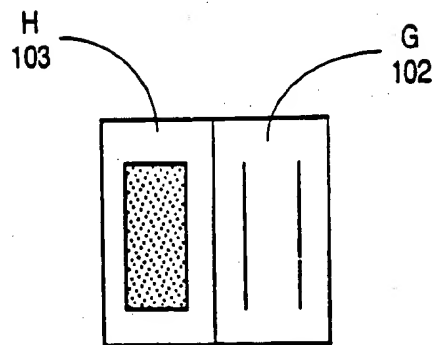


Fig. 11

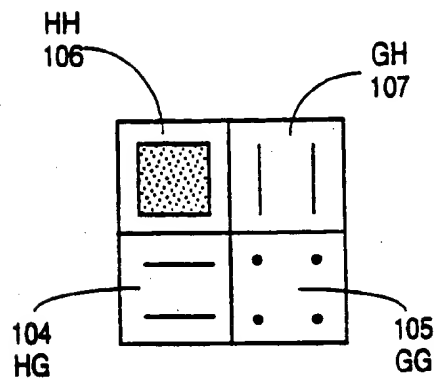


Fig. 14

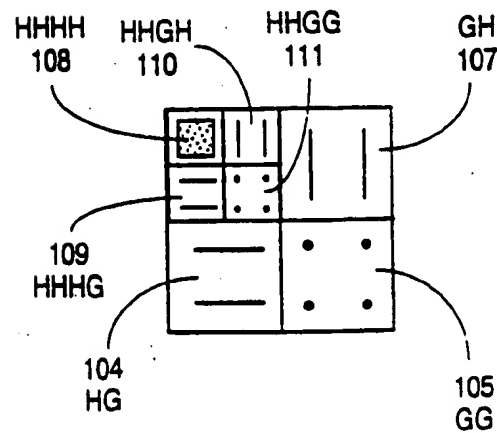


Fig. 15

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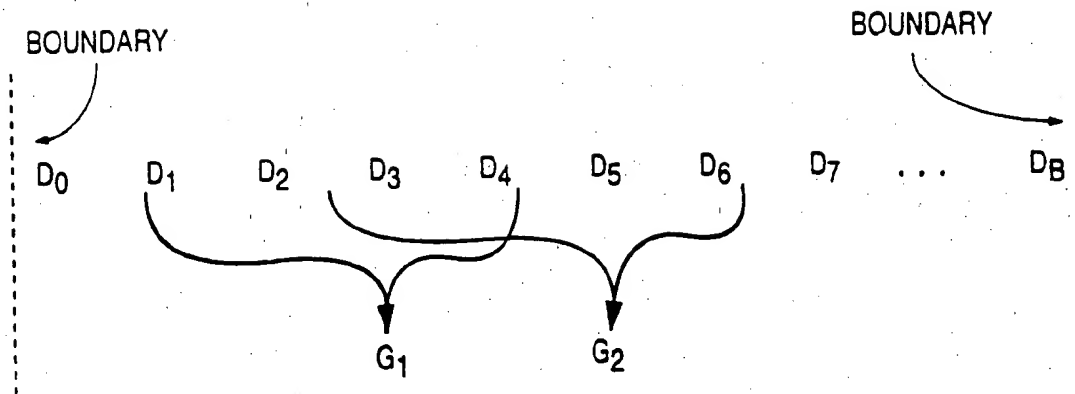


Fig. 12

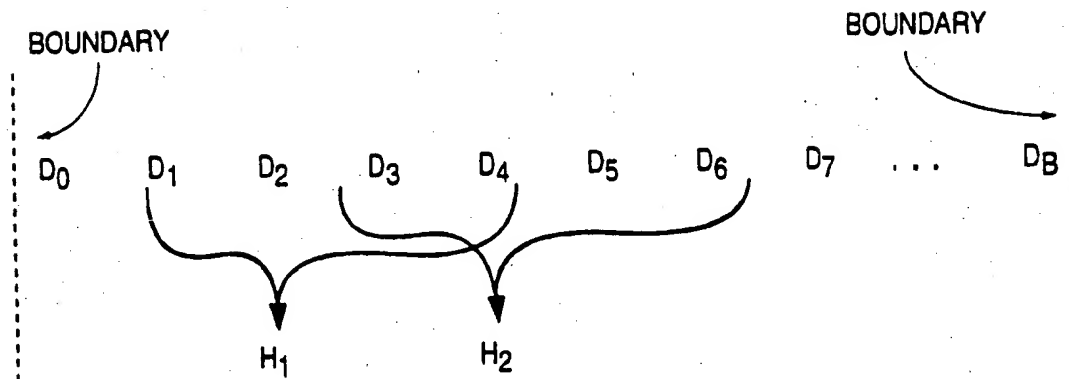


Fig. 13

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	COLUMN										
	0	1	2	3	4	5	6	7	8	9	B
0	D00	D01	D02	D03	D04	D05	D06	D07	D08	D09	D0A D0B
1	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D1A D1B
2	D20	D21	D22	D23	D24	D25	D26	D27	D28	D29	D2A D2B
3	D30	D31	D32	D33	D34	D35	D36	D37	D38	D39	D3A D3B
4	D40	D41	D42	D43	D44	D45	D46	D47	D48	D49	D4A D4B
5	D50	D51	D52	D53	D54	D55	D56	D57	D58	D59	D5A D5B
6	D60	D61	D63	D63	D64	D65	D66	D67	D68	D69	D6A D6B
7	D70	D71	D72	D73	D74	D75	D76	D77	D78	D79	D7A D7B
8	D80	D81	D82	D83	D84	D85	D86	D87	D88	D89	D8A D8B
9	D90	D91	D92	D93	D94	D95	D96	D97	D98	D99	D9A D9B
A	DA0	DA1	DA2	DA3	DA4	DA5	DA6	DA7	DA8	DA9	DAA DAB
B	DB0	DB1	DB2	DB3	DB4	DB5	DB6	DB7	DB8	DB9	DBA DBB

R
O
W

Fig. 16

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COLUMN												
	0	1	2	3	4	5	6	7	8	9	A	B
0	HH00	GH00	HH01	GH01	HH02	GH02	HH03	GH03	HH04	GH04	HH05	GH05
1	HG00	GG00	HG01	GG01	HG02	GG02	HG03	GG03	HG04	GG04	HG05	GG05
2	HH10	GH10	HH11	GH11	HH12	GH12	HH13	GH13	HH14	GH14	HH15	GH15
3	HG10	GG10	HG11	GG11	HG12	GG12	HG13	GG13	HG14	GG14	HG15	GG15
4	HH20	GH20	HH21	GH21	HH22	GH22	HH23	GH23	HH24	GH24	HH25	GH25
5	HG20	GG20	HG21	GG21	HG22	GG22	HG23	GG23	HG24	GG24	HG25	GG25
6	HH30	GH30	HH31	GH31	HH32	GH32	HH33	GH33	HH34	GH34	HH35	GH35
7	HG30	GG30	HG31	GG31	HG32	GG32	HG33	GG33	HG34	GG34	HG35	GG35
8	HH40	GH40	HH41	GH41	HH42	GH42	HH43	GH43	HH44	GH44	HH45	GH45
9	HG40	GG40	HG41	GG41	HG42	GG42	HG43	GG43	HG44	GG44	HG45	GG45
A	HH50	GH50	HH51	GH51	HH52	GH52	HH53	GH53	HH54	GH54	HH55	GH55
B	HG50	GG50	HG51	GG51	HG52	GG52	HG53	GG53	HG54	GG54	HG55	GG55

Fig. 17

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COLUMN													
	0	1	2	3	4	5	6	7	8	9	A	B	
R	0	HHHH00	GH00	HHGH00	GH01	HHHH01	GH02	HHGH01	GH03	HHHH02	GH04	HHGH02	GH05
O	1	HG00	GG00	HG01	GG01	HG02	GG02	HG03	GG03	HG04	GG04	HG05	GG05
W	2	HHHG00	GH10	HHGG00	GH11	HHHG01	GH12	HHGG01	GH13	HHHG02	GH14	HHGG02	GH15
	3	HG10	GG10	HG11	GG11	HG12	GG12	HG13	GG13	HG14	GG14	HG15	GG15
	4	HHHH10	GH20	HHGH10	GH21	HHHH11	GH22	HHGH11	GH23	HHHH12	GH24	HHGH12	GH25
	5	HG20	GG20	HG21	GG21	HG22	GG22	HG23	GG23	HG24	GG24	HG25	GG25
	6	HHHG10	GH30	HHGG10	GH31	HHHG11	GH32	HHGG11	GH33	HHHG12	GH34	HHGG12	GH35
	7	HG30	GG30	HG31	GG31	HG32	GG32	HG33	GG33	HG34	GG34	HG35	GG35
	8	HHHH20	GH40	HHGH20	GH41	HHHH21	GH42	HHGH21	GH43	HHHH22	GH44	HHGH22	GH45
	9	HG40	GG40	HG41	GG41	HG42	GG42	HG43	GG43	HG44	GG44	HG45	GG45
A		HHHG20	GH50	HHGG20	GH51	HHHG21	GH52	HHGG21	GH53	HHHG22	GH54	HHGG22	GH55
B		HG50	GG50	HG51	GG51	HG52	GG52	HG53	GG53	HG54	GG54	HG55	GG55

Fig. 18

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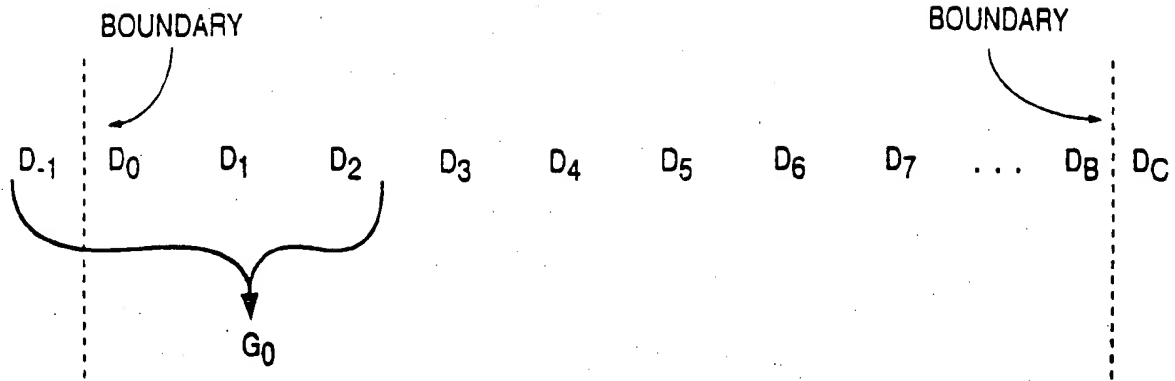


Fig. 19

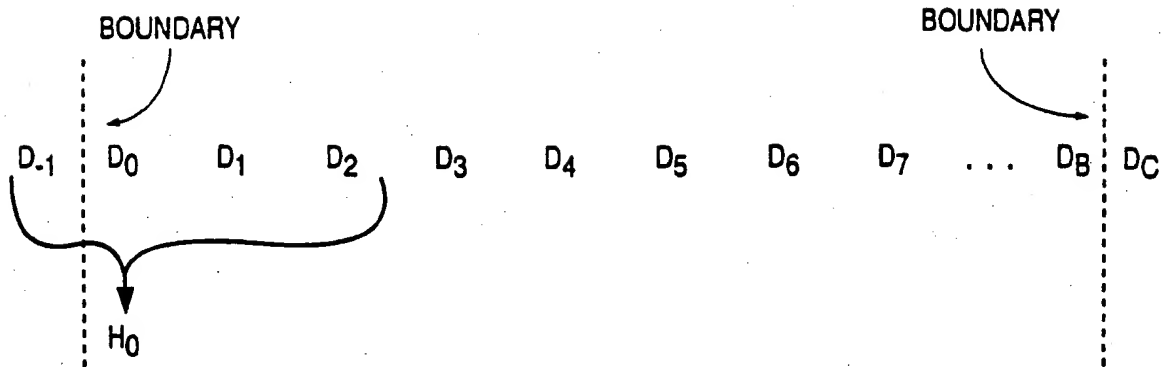


Fig. 20

10/24

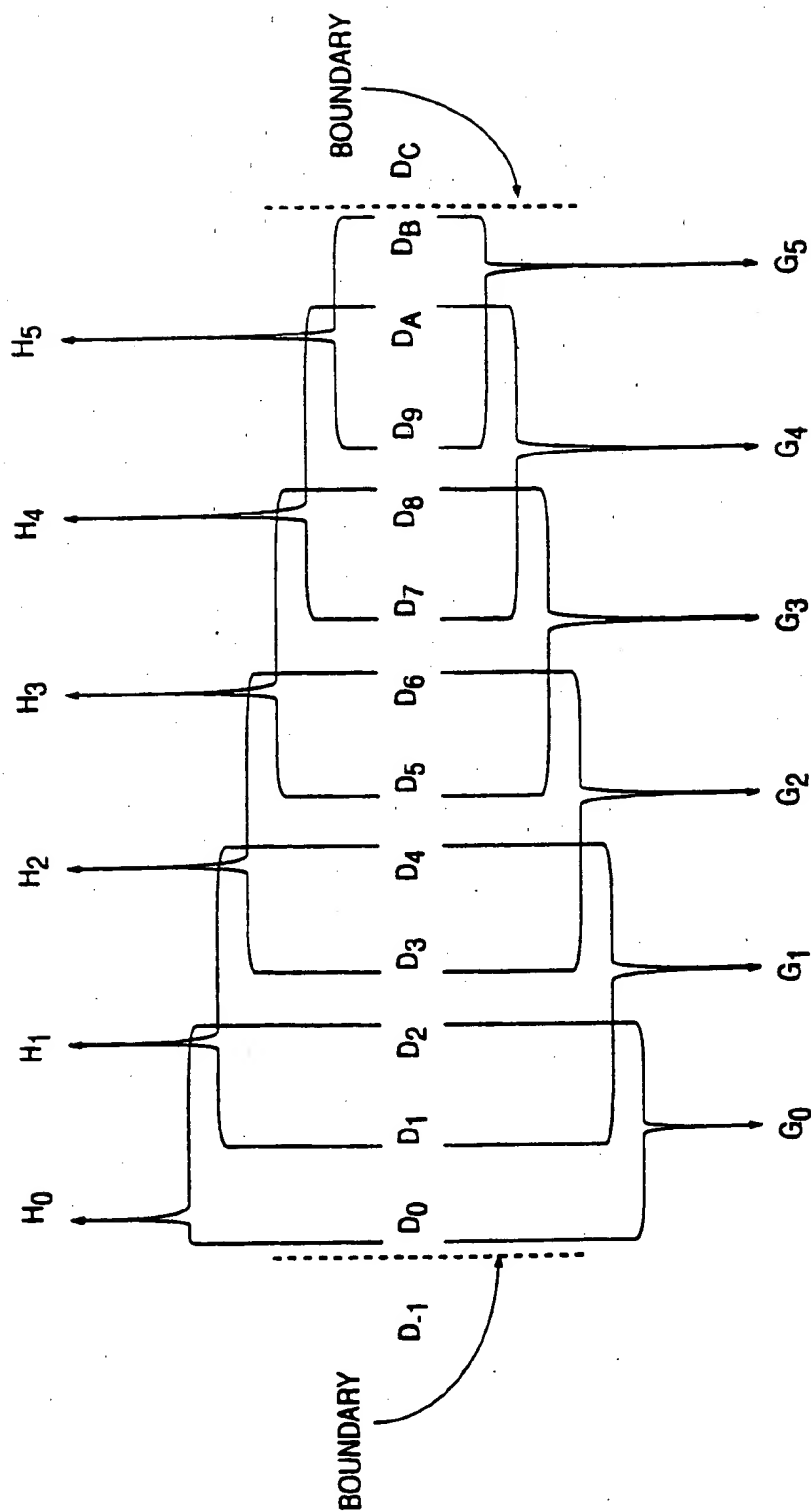


Fig. 21

11/24

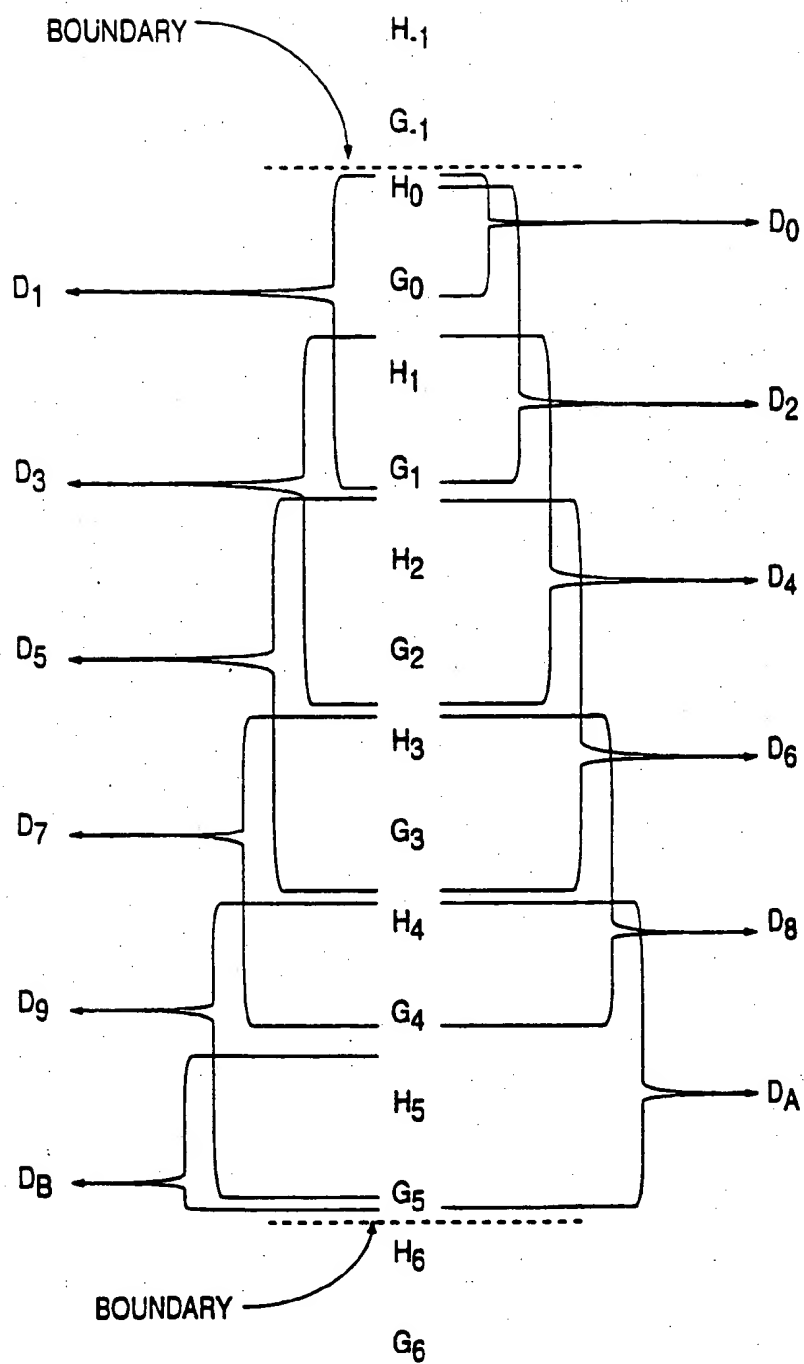


Fig. 22

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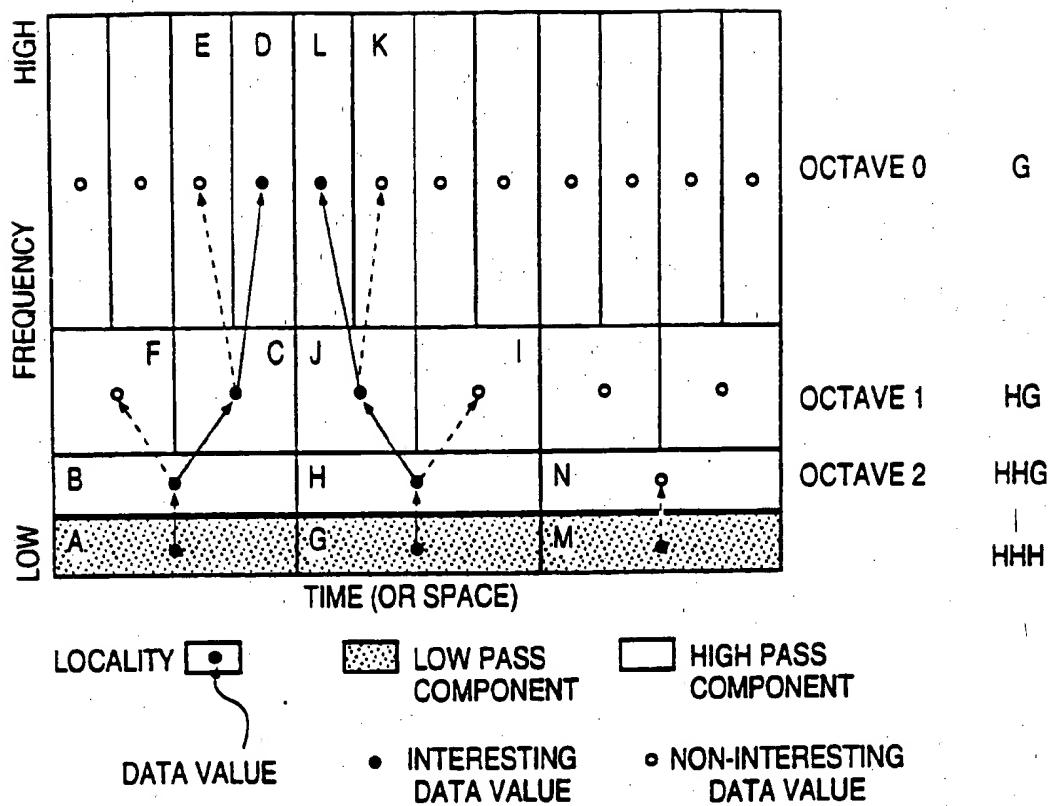


Fig. 23

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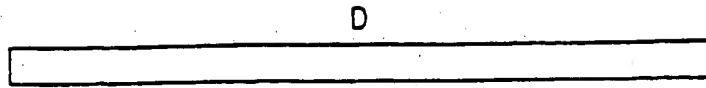


Fig. 24A

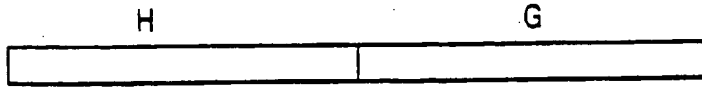


Fig. 24B

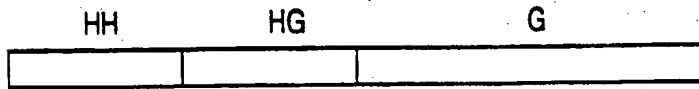


Fig. 24C

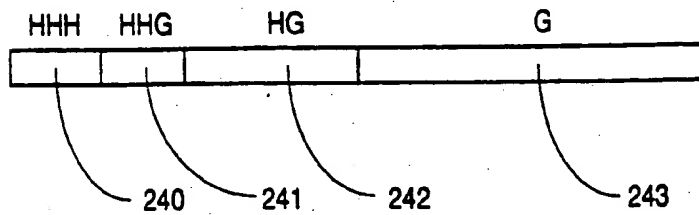


Fig. 24D

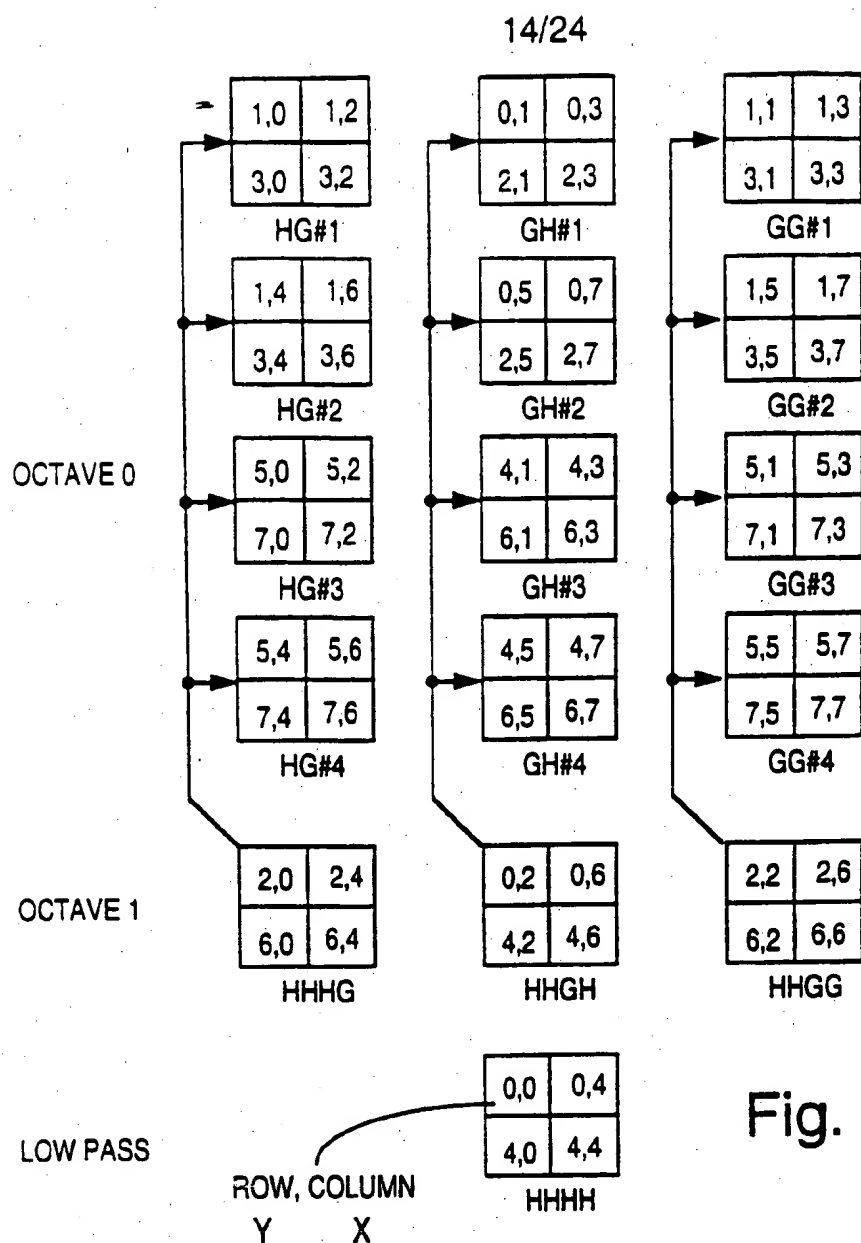
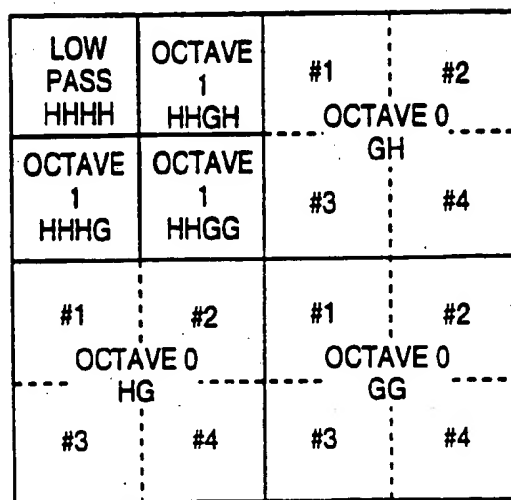


Fig. 25



PICTORIAL REPRESENTATION

Fig. 26

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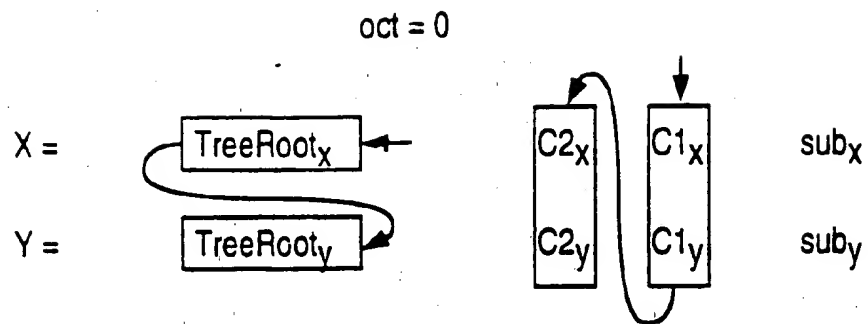


Fig. 27

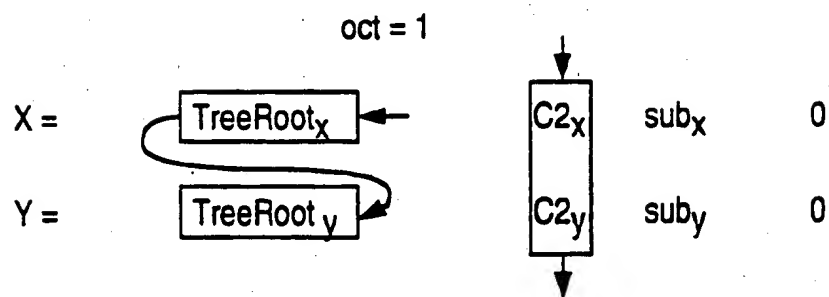


Fig. 28

sub-band		sub _x	sub _y
low pass	{ HH	0	0
	{ HG	0	1
high pass	{ GH	1	0
	{ GG	1	1

Fig. 29

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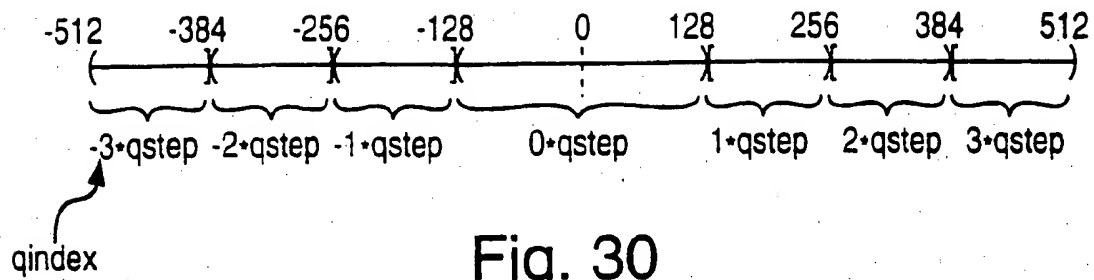


Fig. 30

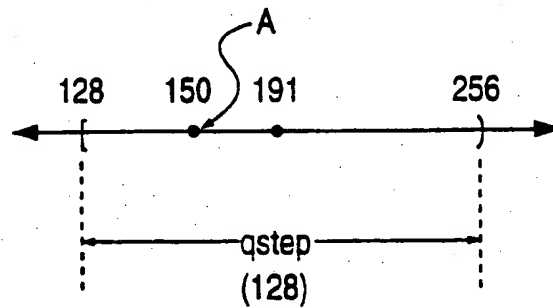


Fig. 31

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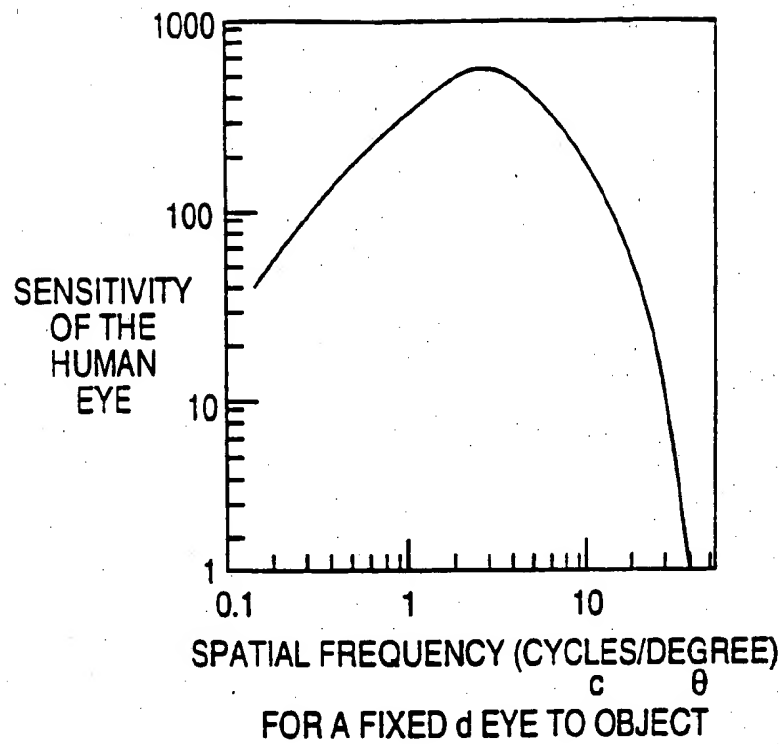


Fig. 32

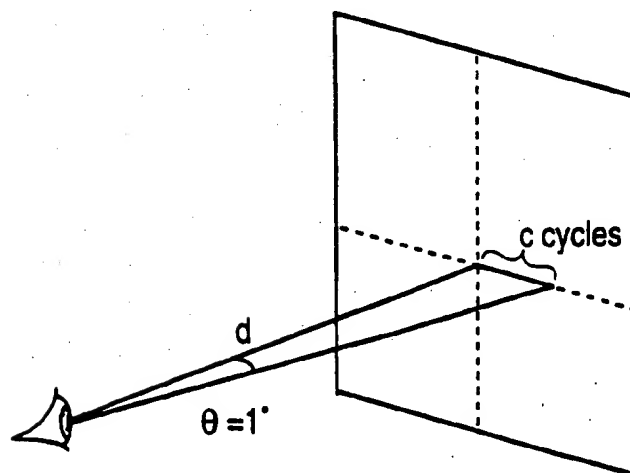


Fig. 33

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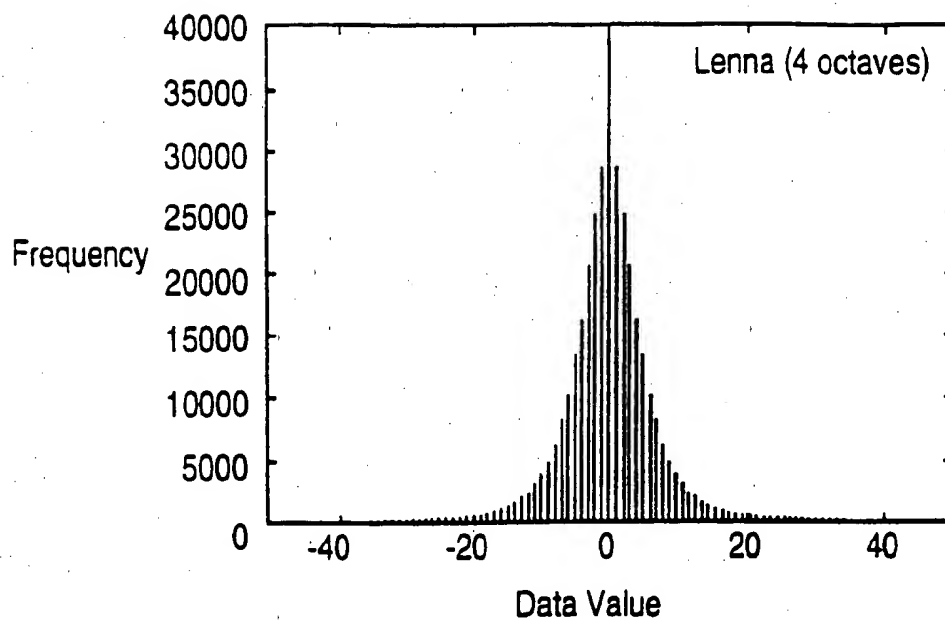


Fig. 34

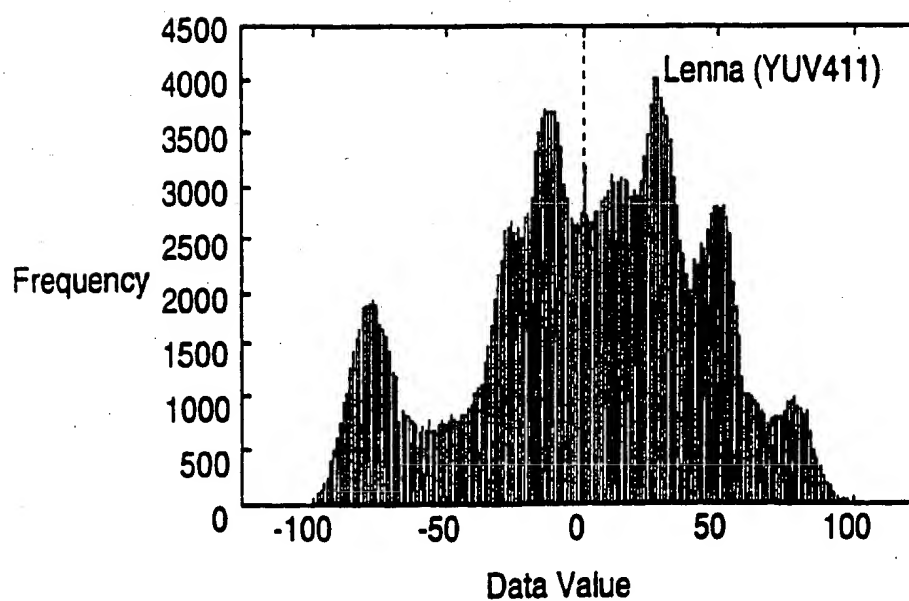


Fig. 35

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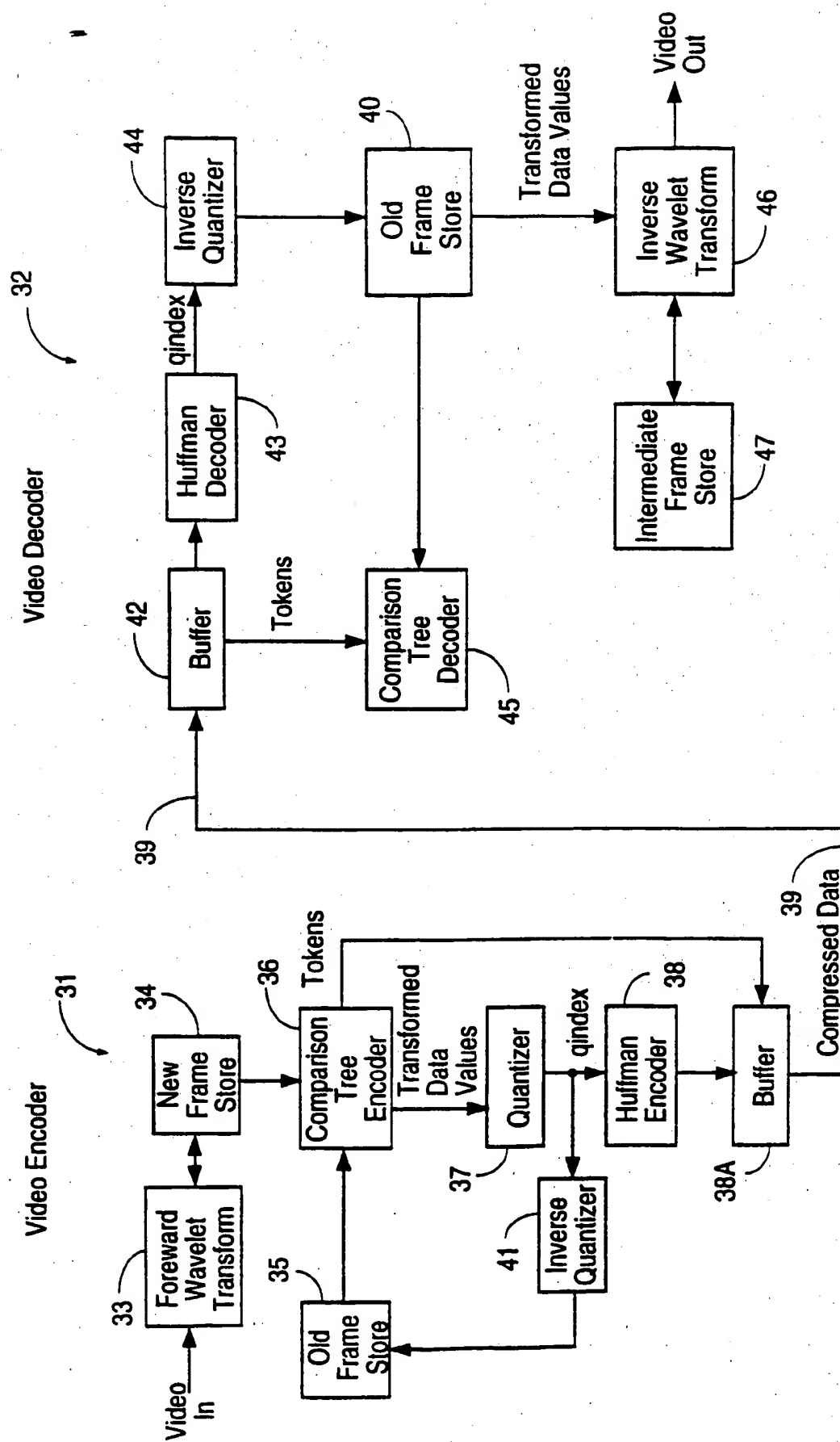


Fig. 36

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MODES OF VIDEO ENCODER AND VIDEO DECODER

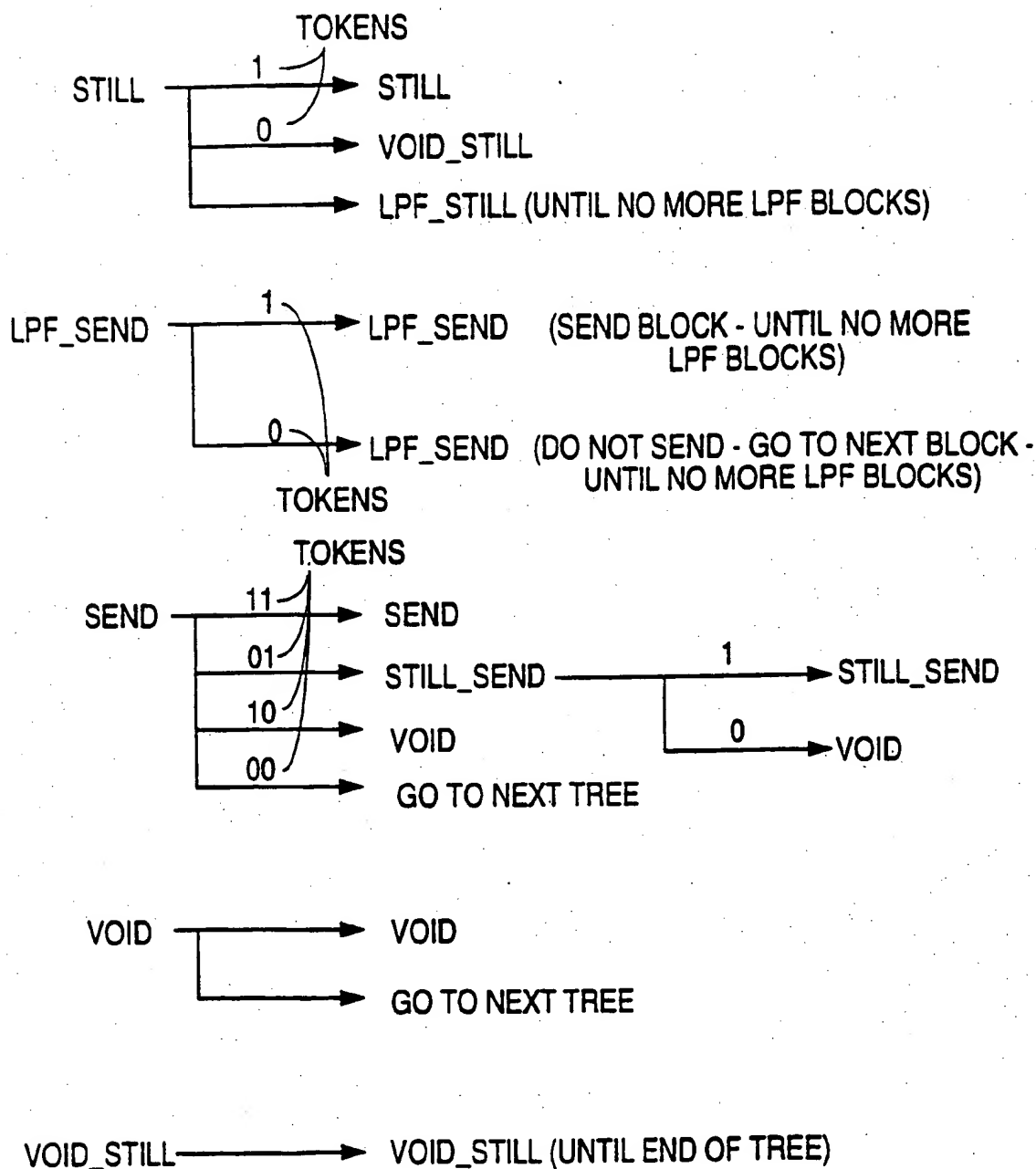


Fig. 37

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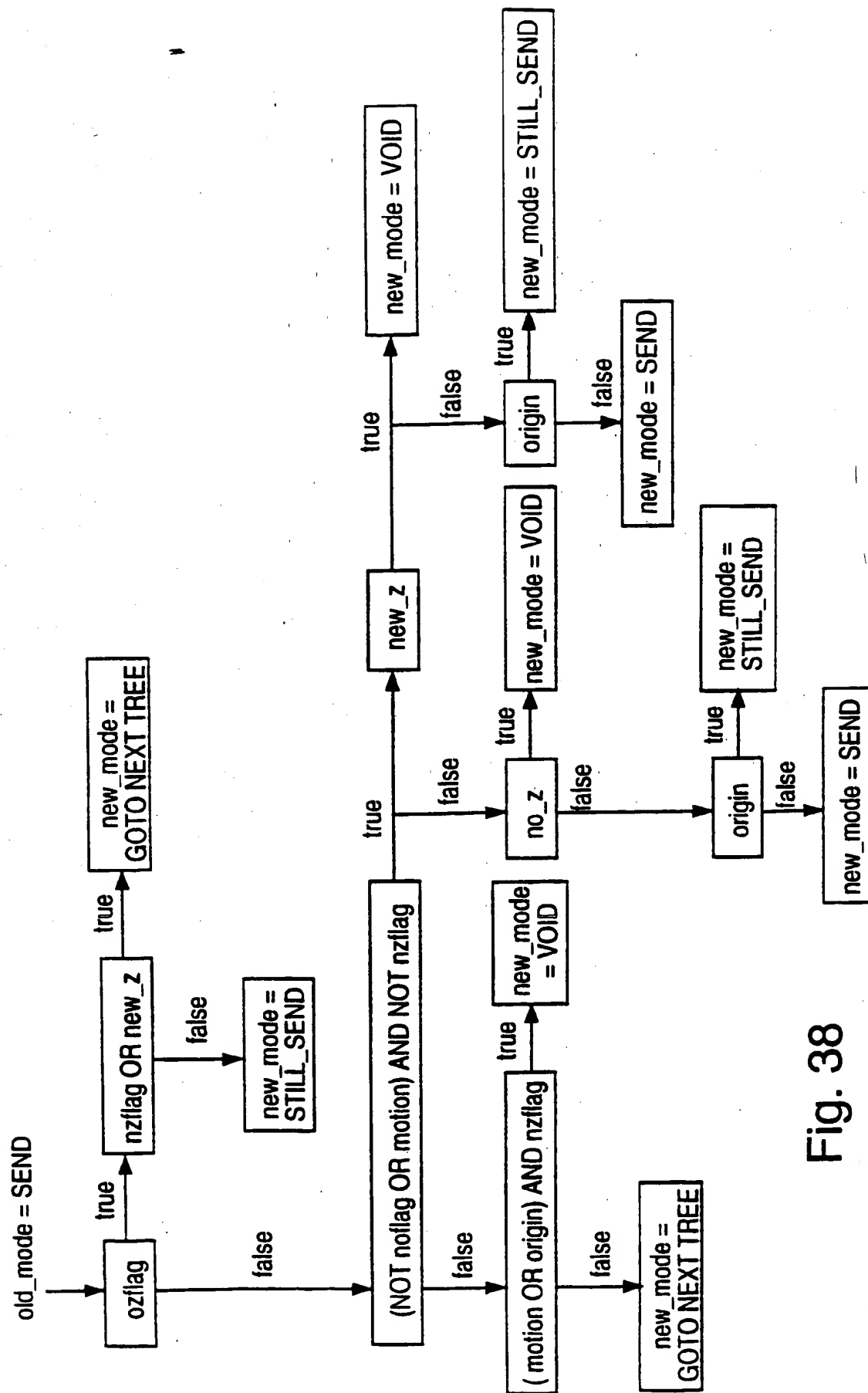


Fig. 38

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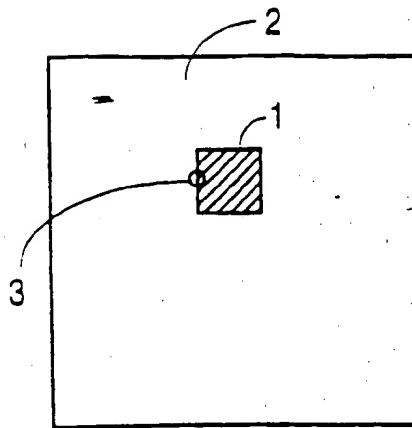


Fig. 39

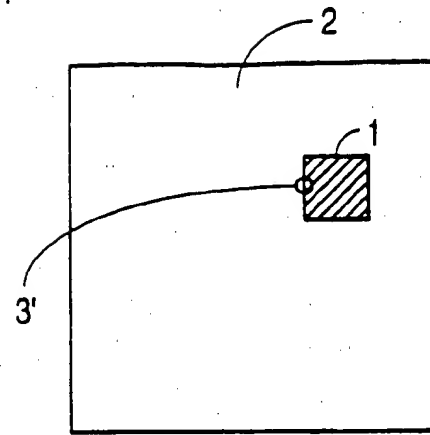


Fig. 40

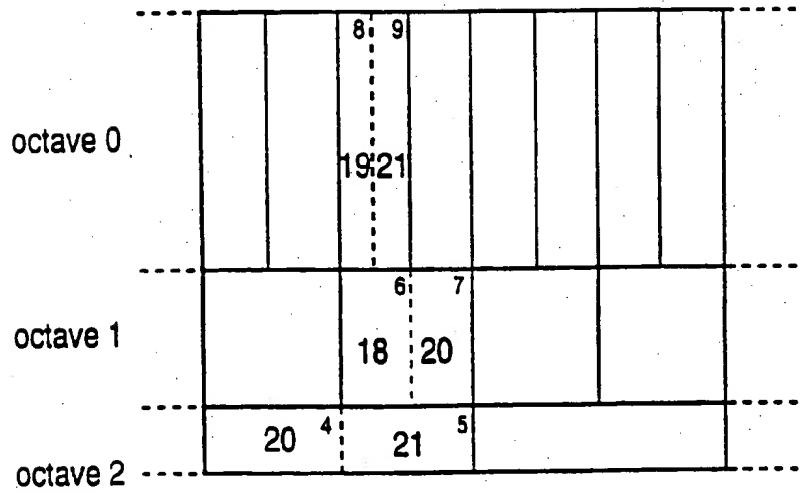


Fig. 41

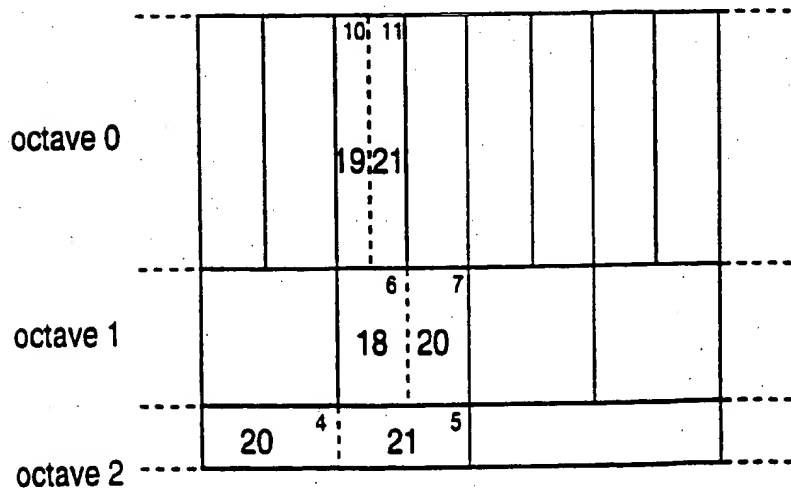


Fig. 42

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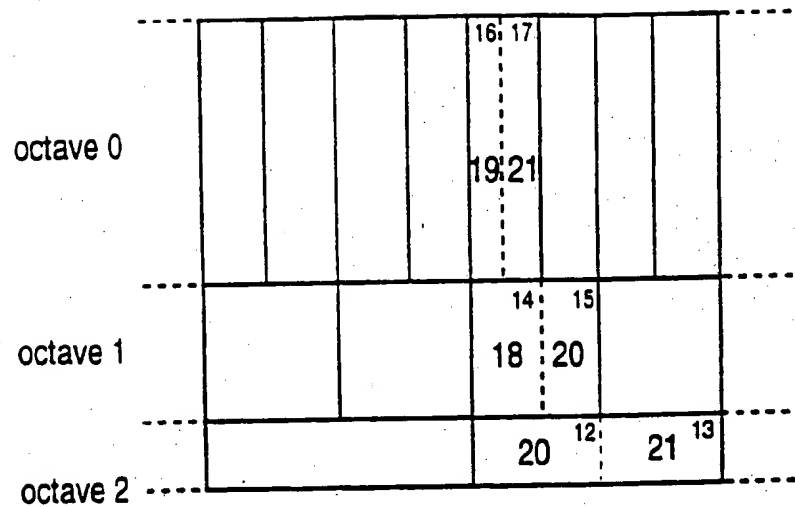


Fig. 43

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VARIABLE - LENGTH TOKENS

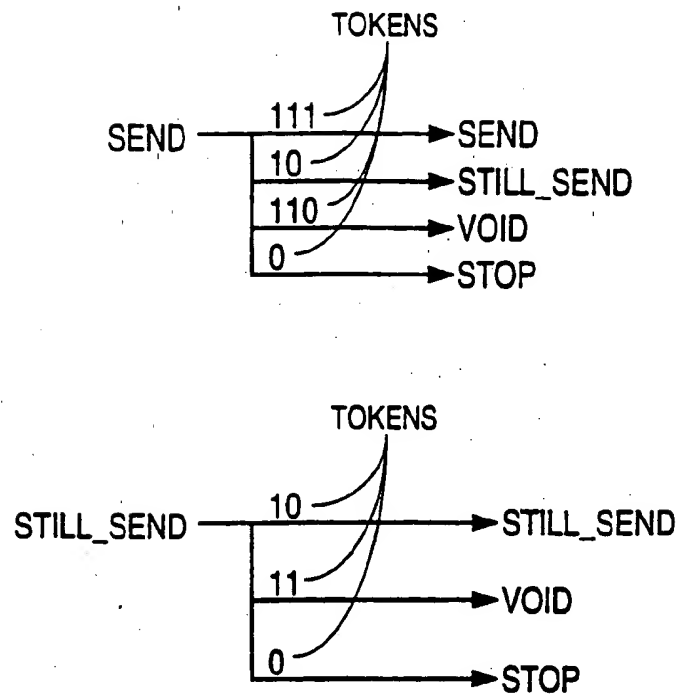


FIG. 44